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Laboratory observations on tidal network growth and development

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We present the results of laboratory experiments carried out in a large experimental apparatus aimed at reproducing a typical lagoonal environment subject to tidal forcings. The experiments were designed in order to improve our understanding of the main processes governing tidal network initiation and its progressive morphodynamic evolution. In particular, the experiments summarized herein aimed at understanding the physical processes, as well as boundary and initial conditions, which lead to the initiation and subsequent development of a tidal channel network, starting from a plane horizontal tidal flat located behind a barrier island and connected through the sea by a single inlet. During the experiments we observed the growth and development of tidal networks and analyzed their most relevant geomorphic features, taking into account the role played by the characteristics of the tidal forcing in driving the development of channelled patterns.
The experimental evidence suggests that general network evolution is substantially characterized by three processes: (1) channel elongation via headward growth, driven by the exceedance of a critical bottom shear stress; (2) incision and sinuosity gradually increasing with channels age; (3) formation of new lateral creeks and tributaries. The lack of external sediment supply, the absence of vegetation, and the prevalence of bedload transport prevented any deposition processes and lateral surface accretion, attributing a purely erosive character to the experimental lagoon. Nevertheless, the morphodynamic feedbacks occurring in the erosional case are essentially the same that occur under depositional conditions. In fact, in both cases, channel excavation is closely connected to concentration of tidal fluxes within the channel network during maximum ebb phase when maximum velocities and shear stresses are reached. In this experimental lagoon the main morphodynamic process responsible for tidal network initiation and development is the differential erosion between the channels and the adjacent surface.
The synthetic networks display geomorphic features which compare favourably with those of actual networks, thus emphasizing that our experimental framework is a useful tool for analyzing the processes governing the formation and evolution of tidal networks. In particular, the synthetic networks display width-to-depth ratios and seaward exponential widening and deepening in accordance with observational evidence. Furthermore they reproduce statistical network characteristics of geomorphic relevance, such as the exponential probability distribution of unchanneled path lengths.
Finally, we analyze the effects of mean sea level variations on channel network dynamics, focusing on the changes of the relevant geomorphic characteristics of the experimental networks, such as e.g. probability distributions of unchanneled lengths and flowing tidal prisms.