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Controls on flood and sediment wave propagation

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The understanding of flood wave propagation – celerity and transformation – through a fluvial system is of generic importance for flood forecasting/mitigation. In association with flood wave propagation, sediment wave propagation may induce local erosion and sedimentation, which will affect infrastructure and riparian natural habitats. Through analysing flood and sediment wave propagation, we gain insight in temporal changes in transport capacity (the flood wave) and sediment availability and transport (the sediment wave) along the river channel. Heidel (1956) was amongst the first to discuss the progressive lag of sediment concentration behind the corresponding flood wave based on field measurements. Since then this type of hysteresis has been characterized in a number of studies, but these were often based on limited amount of floods and measurement sites, giving insufficient insight into associated forcing mechanisms.

Here, as part of a project concerned with the hydrological and geomorphic forcing of sediment transfer processes in alpine environments, we model the downstream propagation of short duration, high frequency releases of water and sediment (purges) from a flow intake in the Borgne d'Arolla River in south-west Switzerland. A total of >50 events were measured at 1 minute time intervals using pressure transducers and turbidity probes at a number of sites along the river. We show that flood and sediment wave propagation can be well represented through simple convection diffusion models. The models are calibrated/validated to describe the set of measured waves and used to explain the observed variation in wave celerity and diffusion. In addition we explore the effects of controlling factors including initial flow depth, flood height, flood duration, bed roughness, bed slope and initial sediment concentration, on the wave propagation processes. We show that the effects of forcing mechanisms on flood and sediment wave propagation will lead to different temporal and spatial erosion and deposition patterns. Knowledge of these forcing mechanisms and flood and sediment wave propagation in general can be applied in flow management and infrastructural/ecological development along the river.

Heidel, S. G. (1956). "The progressive lag of sediment concentration with flood waves." Eos, Transactions American Geophysical Union 37(1): 56-66.