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A 1-D Size Specific Numerical Model for Gravel Transport That Includes Sediment Exchange with a Floodplain

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Sedimentary deposits adjacent to rivers can represent important sources and sinks for bed material sediment, particularly on decadal and longer timescales. The Morphodynamics and Sediment Tracers in 1-D model (MAST-1D) is a size-specific sediment transport model that allows for active exchange between channel and floodplain sediment on river reaches of tens to hundreds of kilometers in length. The model is intended to provide a mechanism for performing a first-order assessment of the likely importance of off-channel sediment exchange in controlling decadal-scale geomorphic trends, thereby helping plan and/or prioritize field data collection and higher resolution modeling work. The model develops a sediment budget for short segments of an alluvial valley. Each segment encompasses several active river bends. In each segment, a sediment transport capacity computation is performed to determine the downstream flux of bed material sediment, following the approach of most other 1-D sediment transport models. However, the model differs from most other bed evolution models in that sediment can be exchanged with the floodplain in each segment, and mass conservation is applied to both the active layer and floodplain sediment storage reservoirs. The potential for net imbalances in overall exchange as well as the size specific nature of the computations allows the model to simulate reach-scale aggradation/degradation and/or changes in bed texture. The inclusion of fine sediment in the model allows it to track geochemical tracer material and also provides a mechanism to simulate, to first order, the effects of changes in the supply of silt and clay on overall channel hydraulic capacity. The model is applied to a $\sim$40 km reach of the Ain River, a tributary of the Rhône River in eastern France that has experienced a significant sediment deficit as a result of the construction of several dams between 1920 and 1970. MAST-1D simulations result in both incision and the formation of a bed armor near the upstream end of the study reach, where sediment load has been disrupted. The inclusion of active exchange with the floodplain allows the floodplain evolve into a net source of bed material sediment as the channel incises. This effect prevents the sediment deficit from reaching the confluence with the Rhone for several simulated decades. When spatially variable migration rates similar to those measured from aerial photography are used to drive sediment exchange, the model shows complex interaction between bed and bank sediment, with the relatively fine-grained bank sediment supply mobilizing the coarser fraction of the active layer within rapidly shifting portions of the channel. This increases overall transport rates and leads to additional channel incision relative to what is simulated without bank sediment supply in these rapidly shifting reaches. The model is also helpful for evaluating the potential reach-scale effects of gravel augmentation downstream of the dams.