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Non-linearities in Holocene floodplain sediment storage

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Floodplain sediment storage is an important part of the sediment cascade model, buffering sediment delivery between hillslopes and oceans, which is hitherto not fully quantified in contrast to other global sediment budget components. Quantification and dating of floodplain sediment storage is data and financially demanding, limiting contemporary estimates for larger spatial units to simple linear extrapolations from a number of smaller catchments. In this paper we will present non-linearities in both space and time for floodplain sediment budgets in three different catchments. Holocene floodplain sediments of the Dijle catchment in the Belgian loess region, show a clear distinction between morphological stages: early Holocene peat accumulation, followed by mineral floodplain aggradation from the start of the agricultural period on. Contrary to previous assumptions, detailed dating of this morphological change at different shows an important non-linearity in geomorphologic changes of the floodplain, both between and within cross sections.

A second example comes from the Pre-Alpine French Valdaine region, where non-linearities and complex system behavior exists between (temporal) patterns of soil erosion and floodplain sediment deposition. In this region Holocene floodplain deposition is characterized by different cut-and-fill phases. The quantification of these different phases shows a complicated image of increasing and decreasing floodplain sediment storage, which hampers the image of increasing sediment accumulation over time. Although fill stages may correspond with large quantities of deposited sediment and traditionally calculated sedimentation rates for such stages are high, they do not necessary correspond with a long-term net increase in floodplain deposition.

A third example is based on the floodplain sediment storage in the Amblève catchment, located in the Belgian Ardennes uplands. Detailed floodplain sediment quantification for this catchments shows that a strong multifractality is present in the scaling relationship between sediment storage and catchment area, depending on geomorphic landscape properties. Extrapolation of data from one spatial scale to another inevitably leads to large errors: when only the data of the upper floodplains are considered, a regression analysis results in an overestimation of total floodplain deposition for the entire catchment of circa 115%. This example demonstrates multifractality and related non-linearity in scaling relationships, which influences extrapolations beyond the initial range of measurements.

These different examples indicate how traditional extrapolation techniques and assumptions in sediment budget studies can be challenged by field data, further complicating our understanding of these systems. Although simplifications are often necessary when working on large spatial scale, such non-linearities may form challenges for a better understanding of system behavior.