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Modelling hysteresis in the transport of eroded sediment

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Sediment transport hysteresis refers to the different sediment fluxes that can occur for the same discharge. For a single rainfall event, the overland flow hydrograph has rising and falling limbs, for which different hysteresis loops have been observed: (i) clockwise, (ii) anti-clockwise and (iii) figure 8 with both flow orientations. It has been suggested that the shape of these loops can be used to identify the different processes of runoff and sediment transport and the sediment source area. We present simulations carried out using the Hairsine-Rose (HR) soil erosion model that reproduce all of the above hysteresis loops for flow conditions that are straightforward to establish in a laboratory soil-erosion flume Based on the HR model, it is possible to explain the causes of the various types of hysteresis loops, in particular the role of the particle size distribution and the deposited layer of previously eroded sediment. Both of these aspects of the HR model, which are not typically included in commonly used erosion models, are crucial to produce these loops. Furthermore, we found that more involved hysteresis patterns do not depend on complicated rainfall distributions. Instead, spatial distributions of deposited sediment from a previous erosion event play a dominant role in determining the overall form and shape of the loop.