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An empirical sediment-discharge hysteresis model for analysing dominant erosion processes, heterogeneity and knowledge gaps

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One phenomenon commonly encountered in temperate erosion studies, but not well understood, is the hysteretic behaviour between sediment concentration and discharge observed in hydrological pathways. This hysteretic behaviour has variously been attributed to the temporal interplay of near and distant sediment sources, the change of particle size distributions within events, and the spatial dynamics of soil saturation and therefore extent, erosivity and transport capacity of drain and overland flow. It is currently impossible to disentangle the dominant factor or combination of factors controlling the behaviour in individual events. In this paper, we take a top-down look at hysteretic behaviour and propose an empirical hysteresis model as a way of quantifying it. First of all, by estimating model parameters for individual events from the data, we are able to quantify the variety of observed hysteretic behaviour formally through different parameter values. Parameter estimates are found to vary in time (between events) as well as in space (between experimental fields set up as replicates). In correlating estimated parameter values with other measurable field characteristics, such as an antecedent precipitation index as a surrogate for soil moisture, we then begin to analyse the dominant factors controlling the temporal dynamics of soil erosion. We further quantify the change of hysteretic behaviour in space as we move from a field at the top of a catchment to the outlet, and begin to infer the dominant processes happening in between. Another novelty of this research is that our analysis is embedded in an uncertainty estimation framework which incorporates data uncertainties and multiple model structures as well as the parameter uncertainties resulting from imperfect data and models.