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Linking hysteresis patterns and variations in suspended sediment sources in a highly urbanized river: a case of the River Aire, UK

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The natural sediment balance of rivers is often disturbed as a result of increased fine sediment influx from soil erosion and/or modifications to the river channel and floodplains, causing numerous problems related to ecology, water quality, flood risk and infrastructure. It is of great importance to understand fine sediment dynamics in rivers in order to manage the problems appropriately. However, despite decades of research, our understanding of fine sediment transport is not yet sufficient to fully explain the spatial and temporal variability in sediment concentrations in rivers. To this end, the study aims to investigate the importance of sediment source variations to explain hysteresis patterns in suspended sediment transport. A sediment fingerprinting technique based on infrared spectrometry was applied in the highly urbanized River Aire catchment in northern England to identify the dominant sources of suspended sediment. Three types of potential sediment source samples were collected: soil samples from pasture in three lithological areas (limestone, millstone grit and coal measures), eroding riverbanks and urban street dust. All source samples were analyzed with Diffuse Reflectance Infrared Fourier Transform spectrometry (DRIFTS). Discriminant analysis demonstrated that the source materials could be discriminated based on their respective infrared spectra. Infrared spectra of experimental mixtures were then used to develop statistical models to estimate relative source contributions from suspended sediment samples. Suspended sediment samples were collected during a set of high flow events between 2015 and 2016, showing different hysteresis patterns between suspended sediment concentration and discharge. The fingerprinting results suggest that pasture from the limestone area is the dominant source of fine sediment. However, significant variations in source contributions during and between events are present. Small events, in terms of discharge, are marked by relatively high contributions of urban street dust, while high stream flows correspond with higher sediment contributions from riverbanks and pasture. Seasonal variations in the dominant sources are also present. The results emphasize the importance of capturing sediment source variations to gain better insights into the drivers of fine sediment transport over various timescales.