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High-temporal Resolution Sediment Fingerprinting with Uncertainty: A Bayesian Approach

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A high-temporal resolution fluvial sediment source apportionment model, set within an empirical Bayesian framework, is presented for the River Wensum Demonstration Test Catchment (DTC), UK. Direct X-ray fluorescence (XRF) and diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS) analysis of sediment covered filter papers were used in conjunction with ISCO automatic water samplers to monitor suspended particulate matter (SPM) geochemistry at high-temporal resolution throughout the progression of five heavy precipitation events during 2012-2013. Exploiting the spatial and temporal variation in four potential sediment source areas and SPM geochemistry respectively, we are able to apportion sediment contributions from eroding stream channel banks, arable topsoils, damaged road verges and agricultural field drains at 60-120 minute resolution. For all monitored precipitation episodes, pre- and post-event conditions are dominated by elevated SPM calcium concentrations that indicate major sediment inputs from carbonate-rich subsurface sources. Conversely, precipitation events coincide with an increase in concentrations of clay-associated elements and a consequent increase in predicted contributions from surface sources. Employing a Gibbs sampling Markov Chain Monte-Carlo mixing model procedure has enabled full characterisation of both spatial geochemical variability and instrument precision to quantify uncertainty around posterior distributions. All model source apportionment estimates correspond favourably with understanding of the regional geology, analysis of hysteresis behaviour, and visual observations of catchment processes. The results presented here demonstrate how to directly analyse SPM trapped on filter papers by spectroscopy to yield the high-temporal resolution source apportionment estimates required by catchment managers to help mitigate the deleterious effects of land-to-river sediment transfer.