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A storage-extended rating curve for sediment flux estimation

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An empirical suspended sediment concentration (SSC) estimation method was tested, which incorporates sediment storage, erosion, and sedimentation history of the upstream river system. It is based on the common rating curve method of which inaccurate SSC estimation is prevailingly caused by the assumption of an over-proportional relationship between SSC and discharge. However, this ignores the fact that SSC depends on the availability of sediments in the river basin as well. Hence, the tested method includes non-linear processes such as the clockwise and counter-clockwise hysteresis during flood discharges. The main characteristic of this new approach is that sediment flux is described as a composition of (i) the base transport of sediments from the catchment area into the river system, (ii) erosion, and (iii) in-situ sedimentation. The first two components are approximated with classical rating curves. The second component depends on (i) a threshold discharge for erosion and (ii) on the sediment availability. Sedimentation is factored as a constant value and it is zero if the discharge exceeds the threshold value. This new model formulation was tested with daily SSC and discharge measurements from the Alpine Rhine River for the period 1 June 2012 to 31 May 2013 at gauging station Diepoldsau, which is located a few kilometres upstream of Lake Constance. The seven empirical parameters of the model were estimated by using an evolutionary algorithm. This optimization algorithm found a threshold for erosion at a discharge of about 500 $m^3\ s^{-1}$, a mean concentration of 124 mg l^{-1} that is lost due to sedimentation, and the mean content of sediment storage in the river bed of about 1.82×10^{11} kg, which is available for erosion. The results show an clear improvement of SSC estimation: R^2 increased to 0.93 while it was 0.73 for the rating curve. Moreover, the new method calculated flood loads, which fitted perfect to measured sediments: e.g. the measured flood load of 7392 mg l^{-1} (4 June 2013) was approximated with 7357 mg l^{-1} by the model. To conclude, the additional consideration of erosion and sedimentation processes significantly improves SSC estimations especially during flood events and it offers a reliable way to estimate SSC time series with runoff data.