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A principal components regression approach to model the spatio-temporal bed evolution of reservoirs

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Sustainable management of water storage reservoirs requires prediction of a long-term behavior of sedimentation in reservoirs. Physically-based numerical models which are commonly used for long-term prediction faces challenges in process complexity, lack of data, as well as high computational costs. An efficient data-driven modeling approach using the principal components regression was investigated for its capability to represent the spatio-temporal dynamics of the bed evolution of a reservoir. A small daily storage reservoir on the River-Iller of Germany, Lautrach Reservoir, was considered for the investigation. The bed-evolution development of the Lautrach reservoir was calibrated and validated over time spans of 5 years using a depth averaged advective-dispersive model (TELEMAC modeling system). The daily bed-evolution at the numerical grid points through the simulation periods were taken for the principal components analysis. The bed-evolution of the reservoir were sufficiently represented by the first four principal components contributing to some 90 % of the total variance. A tremendous reduction in the dimensionality of data-base from order of thousands to four components was found to be quite efficient in subsequent statistical analysis. The regression models based on the multiple linear regressions between the eigenvectors of the first four principal components with the inflow discharge, input suspended sediment concentration, and differential discharge were able to reconstruct the spatio-temporal bed-evolution of the physically-based model results in an excellent manner. Correlation coefficient between the numerical and principal component

regression was found to be 0.98 for the calibration step (1992-1996), 0.99 for the validation step (1996-2001), and 0.84 for the prediction data step (2005-2025). Predictions with similar conditions of data and initial morphological condition were found to perform reasonably well over a medium period (10 years). The approach is novel and opens a new research direction towards the assimilation of data and dynamics in the prediction of long-term simulation of reservoir sedimentation at lower computational efforts as compared to the physically-based modeling approach. The research can further be extended by considering the non-linear regression approach, auto-regressive moving average methods to account the dynamics of reservoir responses.