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A multiple-state discrete-time Markov chain for estimating suspended sediment concentrations in open channel flow

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In this study, transport processes of uniform size sediment particles under steady and uniform flow are described by the multi-state discrete-time Markov chain. The multi-state discrete-time Markov chain is employed to estimate the suspended sediment concentration distribution versus water depth for various steady and uniform flow conditions. Model results are validated against available measurement data and the Rouse profile. Moreover, the multi-state discrete-time Markov chain can be used to quantify the average time spent for the flow to reach the dynamic equilibrium of particle deposition and entrainment processes. In the first part of this study, suspended sediment concentration under three different flow conditions are discussed. As the Rouse number decreases, the difference between the suspended sediment concentration estimated by the Markov chain model and the Rouse profile becomes more significant, and such discrepancy can be observed at a larger relative height from the bed. It can be attributed to the fact that the use of the terminal settling velocity in the transport process can lead to underestimation of the model residence probability and overestimation of the deposition probability. In the second part, laboratory experiments are used to validate the proposed multi-state discrete-time Markov chain model. It is observed that it would take more time for the sediment concentration to reach a dynamic equilibrium as the Rouse number decreases. In addition, the flow depth is found to be a contributing factor that impacts the time spent to reach the concentration dynamic equilibrium. It is recognized that the performance of the proposed multi-state discrete-time Markov chain model relies significantly on the knowledge of the vertical distribution of the turbulence intensity.