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Solute dispersion in open channel flow with bed absorption

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Reactive solute dispersion is of essential significance in various ecological and environmental applications. It is only qualitatively known that boundary absorption depletes pollutant around the boundary and reduces the concentration nearby. All the existing studies on this topic have been focused on the longitudinally distributed mean concentration, far from enough to fully characterize the transport process with tremendous cross-sectional concentration nonuniformity. This work presents an analytical study of the evolution of two-dimensional concentration distribution for solute dispersion in a laminar open channel flow with bed absorption. The fourth order Aris-Gill expansion proposed in our previous study (Wang and Chen, 2016b. Int. J. Heat Mass Trans., 95, 131-141.) is further extended for the case with bed absorption to cover the transitional effects of skewness and kurtosis. Results reveal the extremely nonuniform cross-sectional concentration distribution, and demonstrate that concentration at the bed instead of the mean should be used for reliable quantification of the absorption flux. The accurate two dimensional concentration distribution presented in this study brings important environmental implications such as risk assessment associated with peak concentration position and duration of toxic pollutant cloud in open channel waters.