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Untangling hyporheic residence time distributions and whole stream metabolisms using a hydrological process model

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The interaction of the water residence time in hyporheic sediments with the sediment metabolic rates is believed to be a key factor controlling whole stream metabolism. However, due to the methodological difficulties, there is little data that investigates this fundamental theory of aquatic ecology. Here, we report on progress made to combine numerical modeling with a series of manipulation to laboratory flumes overcoming methodological difficulties. In these flumes, hydraulic conditions were assessed using non-reactive tracer and heat pulse sensor. Metabolic activity was measured as the consumption and production of oxygen and the turnover of reactive tracers. Residence time and metabolic processes were modeled using a multicomponent reactive transport code called Min3P and calibrated with regard to the hydraulic conditions using the results obtained from the flume experiments. The metabolic activity was implemented in the model via Monod type expressions e.g. for aerobic respiration rates. A number of sediment structures differing in residence time distributions were introduced in both, the model and the flumes, specifically to model the biogeochemical performance and to validate the model results. Furthermore, the DOC supply and surface water flow velocity were altered to test the whole stream metabolic response. Using the results of the hydrological process model, a sensitivity analysis of the impact of residence time distributions on the metabolic activity could yield supporting proof of an existing link between the two.