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The effect of river fluctuation frequencies and amplitudes on the extent of the river-aquifer mixing zone and on the dilution of substances

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The river-aquifer mixing zone has been identified in the past by both observations in the field and by applying coupled groundwater models. Its implications are important e.g. for macrozoobenthos or fish eggs, which react sensitively to changes in flow velocities. The groundwater quality is also strongly affected due to the transport of substances from the river into the aquifer and can be altered due to these mixing processes. At a field site east of Vienna, we recently found that the Danube River surface level fluctuations induce circular flow patterns within the mixing zone and cause a greater dispersion of substances dissolved in groundwater. This has possibly important implications for river management, for example, in the case of anthropogenic river level fluctuations. In this paper, we investigate these findings more generally for groundwater-river interaction with different river fluctuation amplitudes and frequencies. We apply an unsaturated-saturated groundwater model and perform an extensive systematic model analysis to identify the effects of river fluctuation frequencies and amplitudes on the extent and location of the mixing zone. Thereby we investigate the influence of the river bank slopes, the hydraulic aquifer properties and the exchange conditions (infiltration and groundwater exfiltration). The estimated extents and locations of the mixing zone are presented for a range of river fluctuation frequencies and amplitudes, for aquifers of high to low permeabilities, for flat and steep riverbanks and for infiltration and groundwater exfiltration. These parameters demonstrate the significant correlation to the extent of the mixing zone and can help to give an estimate for management strategies. Furthermore, we give an overview of how much a non-reactive substance dissolved in groundwater is diluted, due to dispersion within the mixing zone, for the full set of scenarios performed during our systematic model analysis.