Vertical distribution of solute input shapes concentration-discharge relations

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Understanding the influence of solute inputs on their export dynamics at the catchment scale is an open challenge hampered by the general lack of distributed and time varying input data. The export dynamics is thus often investigated by analyzing concentration and discharge data at catchment outlets. These data together with knowledge of typical solute source location can provide insights about the export dynamics. We collected concentration and discharge data across 492 catchments in 9 countries and analyzed the solute concentration magnitude and dependence on discharge at the catchment outlet. The observations indicate that solutes with typically higher abundancy in the deeper subsurface have a quite different temporal dynamics and concentration-discharge (C-Q) relation than solutes produced near the surface. We further interpret results from observations by running synthetic experiments with a tracer-aided distributed model. The results clearly show that the depth at which the solute is produced is indeed the key-player in shaping the C-Q relation, especially on solutes exhibiting consistent diluting (Ca, Mg, K, Na, Cl) or weakly enriching (DOC) behavior. Such a generalization is not straightforward when moving to nutrients (NO₃ and PO₄), mostly injected sporadically through point or distributed sources. Their temporal variability is enhanced compared to the other solutes, and it adds uncertainties in the determination of the exponent of the C-Q relation.