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Lagrangian modeling of advective solute transport along hydrological pathways

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With mean properties and mean flow given or resolved by simulations, water and solute transport in a catchment can be analysed in terms of flux/discharge. A Lagrangian framework for material transport along hydrological pathways is presented. Using this framework, we explore generic consequences of space-time flow variations, emphasizing the macro-dispersion along pathways. The solute is released from a finite but limited source (recharge) area. Two issues are of particular interest:

i) Water travel time distributions obtained by forward and backward particle tracking in a space-time varying velocity field;

ii) Conditions for implementing convolution in a space-time varying velocity field.

Trajectories are simulated under generic conditions, with fully ergodic and only spatially ergodic velocity. It is shown that forward (water travel time) and backward (water age) statistical distributions coincide for statistically stationary space-time variations. Temporal variability will generally alter the statistical structure of the Lagrangian velocity fluctuations; once this is accounted for, convolution is applicable provided that independence of transition times between pre-defined segments is approximately valid. Finally, we illustrate the potential effect of space-time velocity fluctuations on tracer attenuation. Further work is needed to better understand the statistical structure of space-time velocity under more realistic scenarios of hydrological transport.