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Reaction rates in randomly stratified media

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Chemical species are advected by water and undergo mixing due to several processes including local diffusion or dispersion. In turn, mixing causes disequilibrium and reactions take place to drive the system back to local equilibrium. Depending on the characteristic times of the processes, in some cases reactions can be assumed instantaneous.

In general, a multicomponent reactive transport problem is described through a set of coupled non-linear partial differential equations. Under instantaneous chemical equilibrium, a complex geochemical problem can be highly simplified by defining the system in terms of conservative quantities, termed components, and the space-time distribution of reaction rates.

We investigate the parameters controlling reaction rates in a heterogeneous aquifer at short distances from the source. Hydraulic conductivity at this scale is modeled as a random process with highly anisotropic correlation structure. We derive closed-form analytical solutions for statistical moments of reaction rates for the particular case of negligible transverse dispersion. Then, we analyze numerically the effect of accounting for transverse local dispersion