Effect of streamline distribution and mixing on reactive processes at the hillslope scale

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Abstract

Subsurface flow patterns exert a significant influence on solute transport and biogeochemical processes at scales ranging from the hyporheic zones to catchments. Consequences on solute turnover and chemical weathering have been often addressed by residence time distribution approaches as different streamlines correspond to broadly distributed residence times. However, understanding the impact of the streamline spatial patterns and the effect of mixing across streamlines on reaction kinetics remains an outstanding challenge.

Here we investigate the impact of surface topography on subsurface streamline patterns and analyse their influence on mixing and reaction processes for different biogeochemical reactions including fluid-fluid and fluid-mineral reactions. We develop both analytical and numerical models that quantify the spatial distribution of streamlines, the distribution of travel times, the rate of mixing across streamlines and the resulting reaction rates. We present a case study at the Guadeloupe Quiock creek observatory, where strontium isotope data are used to quantify the chemical erosion of basalt.