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Implementing a conceptual model of physical and chemical soil profile evolution

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When soil profile composition is generalised in terms of the proportion, p, of bedrock remaining (= 1 – depletion ratio), then other soil processes can also be expressed in terms of p, and 'soil depth' described by the integral of (1-p) down to bedrock. Soil profile evolution is expressed as the advance of a sigmoidal weathering front into the critical zone under the action of upward ionic diffusion of weathering products; downward advection of solutes in percolating waters, with loss of (cleanish) water as evapotranspiration and (solute-laden) water as a lateral sub-surface flow increment; and mechanical denudation increment at the surface. Each component responds to the degree of weathering. Percolation is limited by precipitation, evapotranspiration demand and the degree of weathering at each level in the profile which diverts subsurface flow. Mechanical removal rates are considered to broadly increase as weathering proceeds, as grain size and dilation angle decreases.

The implication of these assumptions can be examined for steady state profiles, for which observed relationships between mechanical and chemical denudation rates; and between chemical denudation and critical zone depth are reproduced. For non-steady state evolution, these relationships break down, but provide a basis for linking critical zone with hillslope/ landform evolution.