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Water in the critical zone: soil, water and life from profile to planet

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Water is essential to the critical zone between bedrock and the atmosphere, and without water the soil is dead. Water provides the basis for the abundant life within the soil and, interacting with micro-organisms, drives the key processes in the critical zone. This review looks at the balances that control the flow of water through the soil, and how water movement is one of the major controls on the fluxes and transformations that control the formation, evolution and loss of material that controls the 'life' and 'health' of the soil.

At regional scales, climate, acting largely through the soil hydrology, plays a major part in determining the type of soils developed – from hyper arid soils dominated by aeolian inputs, through arid and semi-arid soils with largely vertical water exchanges with the atmosphere, to temperate soils with substantial lateral drainage, and humid soils dominated by organic peats.

Soil water balance controls the partition of precipitation between evaporative loss, lateral subsurface flow and groundwater recharge, and, in turn, has a major influence on the potential for plant growth and on the lateral connectivity between soils on a hillslope. Sediment and solute balances distinguish soils of accumulation from soils that tend towards a stable chemical depletion ratio. Reflecting the availability of water and the soil material, carbon balance plays a major role in soil horizonation and distinguishes soils dominated by mineral or organic components.

At finer catena and catchment scales, lateral connectivity, or its absence, determines how soils evolve through the transfer of water and sediment downslope, creating more or less integrated landscapes in a balance between geomorphological and pedological processes.

Within single soil profiles, the movement of water controls the processes of weathering and soil horizonation by ion diffusion, advective leaching and bioturbation, creating horizonation that, in turn, modifies the hydrological responses of both soil and landscape. For example, the soil hydrological regime helps to contrast soils that accumulate more and less soluble constituents of the parent material.