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# Soil Hydrological Processes - A Thermodynamic Perspective

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The soil part of the hydrological cycle connects hydrosphere, atmosphere and terrestrial vegetation through exchange flows of matter and energy. Therefore, an understanding of soil hydrological processes is crucial for the prediction of changes in biogeochemical dynamics on a global scale. Methods from non-equilibrium thermodynamics have not been frequently applied yet in soil hydrological modelling. They provide, however, an additional constraint that is not captured by the energy- and water balance. This constraint is derived from the second law of thermodynamics and implicates that flows of water through the soil produce entropy [1]. The heat emitted by friction during runoff, for instance, corresponds to the entropy production associated with runoff, since the potential energy of the water is irreversibly transformed into energy of lower quality on the way to the oceans. The entropy production associated with a hydrological flow contains additional information about the dynamics of the system, compared to the magnitude of the flow alone. The variability of soil moisture, for example, can be captured by the entropy production of soil water redistribution, since frequent wetting and drying of soil produces more entropy than a uniform wetting throughout the year. This difference cannot be represented by the annual mean soil moisture. Moreover, the entropy production of transpiration can be used to describe the correlation of precipitation and relative humidity. We test these concepts using a bucket model coupled to a simple vegetation model on a global scale.

References:
[1] A. Kleidon and S. Schymanski. Thermodynamics and optimality of the water budget on land: A review. Geophysical Research Letters, 2008.