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A state-dependent parameterization for root-zone – groundwater coupling

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We describe a novel parameterization for the vertical flux between an upper root zone water storage, and a lower groundwater storage, based on the Richards' equation.

Many parsimonious one-dimensional column-based water balance models, such as used in land surface schemes, consists of two water storages. An upper storage representing the root zone, and a lower storage representing the groundwater. Classic analytic formulations for the flux between these storages are based on the net effect of a downward drainage from the root zone (ignoring capillary fringe effects below the root zone), and an upward capillary rise from the groundwater (ignoring the root zone moisture content). Thus, both fluxes are computed taking only one of these storages into account, neglecting information on the state of the other storage.

We apply a Richards' equation based model to compute, for a given soil type, the steady state moisture profile between the root zone and the groundwater, using depth to the groundwater and effective saturation within the root zone as constraints. We show how the resulting fluxes have above mentioned individual drainage or capillary fluxes as limiting values in case the root zone is completely wet, or completely dry, respectively.

We show that the difference between the Richards' equation based fluxes and the analytically derived limit values can be approximated by a simple two-parameter sigmoid function. These parameters are shown to be simple functions of depth to the groundwater table. These results enable the state-dependent transition between gravity drainage and capillary rise fluxes. Thus, the fluxes resulting from numerical solutions to the Richards' equation can be approximated by combining simple analytical results with

an empirical weighting function.

We present details of the methodology, and give examples of the effect of this new parameterization on the long term evolution of a root zone soil moisture within a soil column subjected to a dynamic climatic forcing.