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Drainage flux in water balance models

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Abstract: The drainage flux from soils is an important component of the soil water balance. In many water balance models, drainage is calculated using a cascading bucket approach whereby some proportion of the soil water content in excess of the drained upper limit (DUL) is transferred from one bucket to the one below (Figure 1). For an initially saturated uniform soil, this assumes the drainage water passes progressively down the soil profile, with drainage prioritised from the upper soil layers. However, for a free draining soil this is unlikely to reflect the way the soil actually drains. This was highlighted recently in a review of the soil physics of the MEDLI model (Cook, 2021). The drainage model in MEDLI is taken from EPIC (Williams et al., 1989), which was developed to predict crop yield, and has been used in many water balance models. However, this does not necessarily mean this drainage model is suitable for predicting water and solute fluxes from soil. We will examine the drainage component of the EPIC model for water balance model and compare its predicted water content profiles and fluxes with those from the numerical HYDRUS-1D model, as well as from two well accepted analytical models (model names such as Model F and Model W). The two analytical drainage models consider a free draining profile and the other with a water table at shallow depth.

The drainage from a saturated soil profile was calculated with the HYDRUS-1D model and taken as the true drainage behaviour for the three soil textures considered; viz: a sand, a loam and a clay. These results were then compared for the soil water profiles and the drainage flux for the cascading bucket model (Model C), the free drainage analytical (Model F) and the analytical model of drainage to a water table (Model W). The analytical models resulted in quite different shapes for the water content profile due to the different bottom boundary conditions (and other) assumptions.

For Model C, the results are very dependent on the physical size of buckets (layer thickness) as well as the soil physical properties. Also, since the water cascades down through the sequence of buckets, Model C acts initially as if there is a water table bottom boundary condition. Once the draining front reaches the bottom of the soil profile, it then acts like a free draining boundary condition. This results in water content profiles and fluxes which are both (very) different to the analytical and HYDRUS-1D models. This difference will not necessarily cause a large discrepancy when modelling crop yields, for which Model C was originally developed, but is an issue when this model is used for calculating fluxes water and solutes to groundwater (Figure 1). Comparisons will also be made with the analytical models.

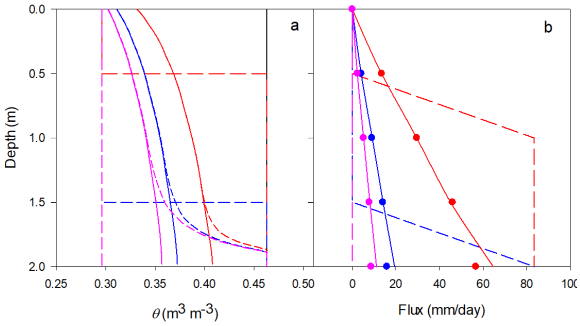

Figure 1. Comparison of drainage with Model C (bucket size 0.5 m) (long dash) with HYDRUS-1D with free drainage (solid lines), water table at 2 m depth (medium dashed lines and solid points) for (a) water content (θ) and (b) flux. Time is 1 day (red), 3 days (blue) and 5 days (pink). The 5 day Model C flux line is zero to 2 m.

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