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Incorporating soil variability in continental soil water modelling: a trade-off between data availability and model complexity

L. Peeters (1), R. S. Crosbie (1), R Doble (1), and A. I. J. M. van Dijk (2)
(1) CSIRO Land and Water, Adelaide, Australia, (2) CSIRO Land and Water, Canberra, Australia

Developing a continental land surface model implies finding a balance between the complexity in representing the system processes and the availability of reliable data to drive, parameterise and calibrate the model. While a high level of process understanding at plot or catchment scales may warrant a complex model, such data is not available at the continental scale. This data sparsity is especially an issue for the Australian Water Resources Assessment system, AWRA-L, a land-surface model designed to estimate the components of the water balance for the Australian continent.

This study focuses on the conceptualization and parametrization of the soil drainage process in AWRA-L. Traditionally soil drainage is simulated with Richards' equation, which is highly non-linear. As general analytic solutions are not available, this equation is usually solved numerically. In AWRA-L however, we introduce a simpler function based on simulation experiments that solve Richards' equation. In the simplified function soil drainage rate, the ratio of drainage (D) over storage (S), decreases exponentially with relative water content. This function is controlled by three parameters, the soil water storage at field capacity (S_{FC}), the drainage fraction at field capacity (K_{FC}) and a drainage function exponent (β).

$$\frac{D}{S} = K_{FC} \exp\left[-\beta(1 - \frac{S}{S_{FC}})\right]$$

To obtain spatially variable estimates of these three parameters, the Atlas of Australian Soils is used, which lists soil hydraulic properties for each soil profile type. For each soil profile type in the Atlas, 10 days of draining an initially fully saturated, freely draining soil is simulated using HYDRUS-1D. With field capacity defined as the volume of water in the soil after 1 day, the remaining parameters can be obtained by fitting the AWRA-L soil drainage function to the HYDRUS-1D results.

This model conceptualisation fully exploits the data available in the Atlas of Australian Soils, without the need to solve the non-linear Richards' equation for each time-step. The spatial distribution of long term recharge and baseflow obtained with a 30 year simulation of historic data using this parameterisation, corresponds well with the spatial patterns of groundwater recharge inferred from field measurements.