Investigating local controls on temporal stability of soil water content using sensor network data and an inverse modelling approach

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Introduction

Soil water content (SWC) is strongly variable both in space and time. A better understanding of the local and nonlocal controls on SWC is a major challenge in modern hydrology. To this end, we employed an extensive wireless sensor network¹ to measure SWC variability in a small grassland head water catchment and to investigate the importance of local controls on SWC temporal stability. For this we coupled the HYDRUS-1D model with shuffled complex evolution (SCE)² algorithm to optimize Mualem-Van Genuchten (VGM) parameters (θᵣ, α, n and Kₛ) from SWC observations at three depths under natural (transient) boundary conditions.

Test site

Inverse model approach

Results

Observed and simulated SWC (1st May 2011 – 1st May 2012)

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Statistic analysis

Relative difference (RD) of soil water content (θᵢ) for location i at time j:

\[ RD_{ij} = \frac{θ_{ij} - θ_j}{θ_j} \]

The mean relative difference (MRD) for location i:

\[ MRD_i = \frac{1}{T} \sum_{j=1}^{T} RD_{ij} \]

Standard deviation of the relative difference (SDRD) for location i:

\[ SDRD_i = \sqrt{\frac{1}{T-1} \sum_{j=1}^{T} (RD_{ij} - MRD_i)^2} \]

Conclusions

I. The inversely calibrated HYDRUS-1D model was able to reproduce the observed time series of SWC reasonably well for both optimization strategies.

II. We found linear relationships between the mean relative difference (MRD) of SWC and θᵣ.

III. The VGM parameter \( log_{10}(K_s) \), n, and \( log_{10}(α) \) were strongly correlated with the MRD of saturation degree for the prior information case.

IV. These results indicate the possibility to infer directly the variability of soil hydraulic properties from temporal stability studies of soil water content.