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Estimation of Hydraulic Parameters with Multi-scale Parameterization Method

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Study question

- Can we estimate hydraulic parameters from soil moisture data monitored in the field?

- It is useful if we can.
- It is difficult and there are small numbers of studies (Vereecken et al., 2008).

Ritter et al. (2003)

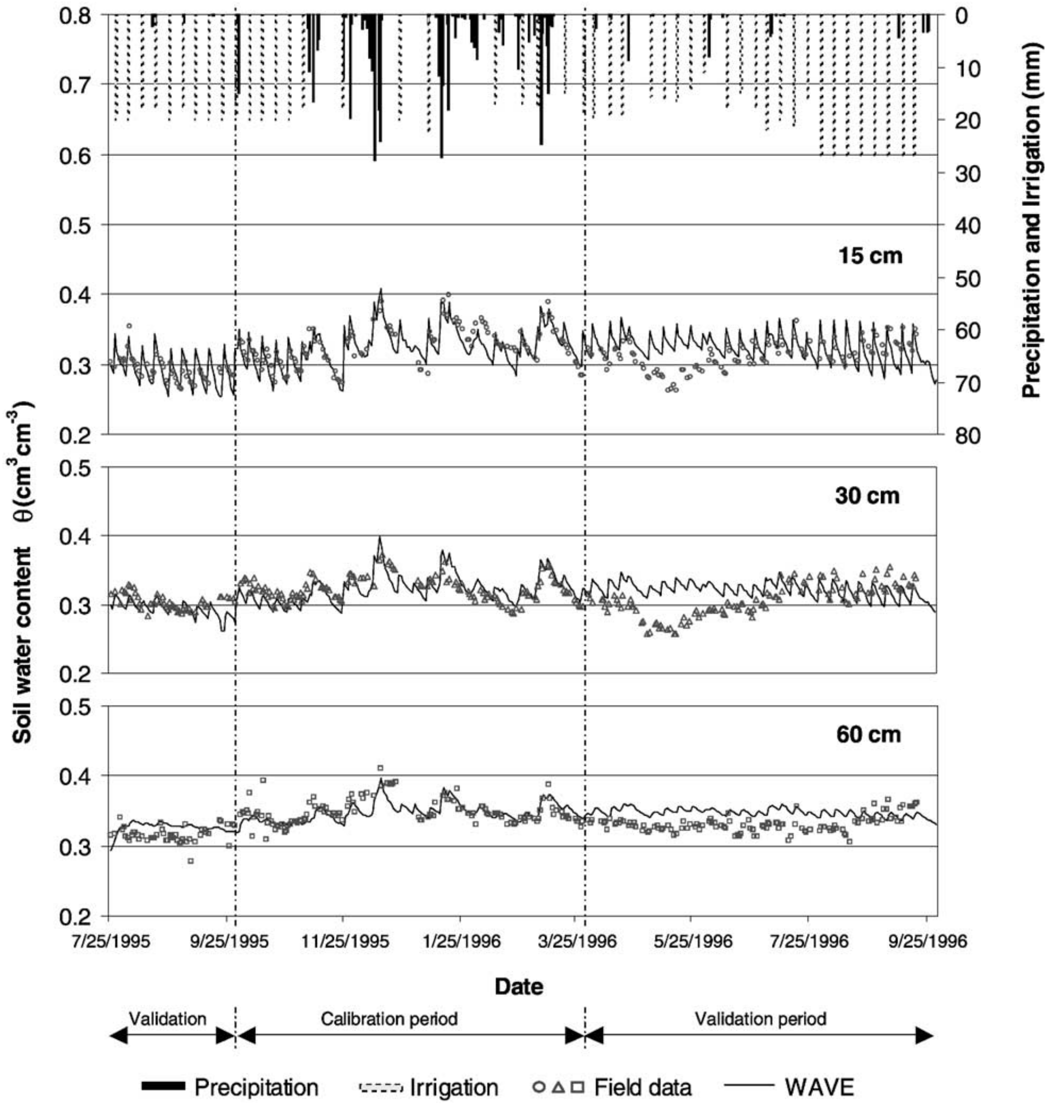


Fig. 4. Soil water content simulation using the parameters of Table 5 estimated by inverse optimization. Measured data (symbols) and WAVE prediction (lines).

Outline of this study

- Hydraulic parameters were estimated with:
  - Field data (Seki et al., 2010)
    Monitored soil water and rainfall intensity at tropical rain forest in Indonesia
  - Numerical simulation (Hayek et al. ,2008)
    Adaptive multi-scale parameterization method

Field site

- Tropical rain forest
- Borneo (Kalimantan) Island, Indonesia (Seki et al., 2010)

HD plot

20 cm (Sand)

30 cm (Sandy loam)

Moisture sensor
FDR probe
ECH_2O, EC-10

K plot

10 cm

20 cm

Analysis

- One-dimensional finite elements methods with Richards equation
- 100 cm height
  - 0.5 cm mesh for upper 50 cm
  - 1 cm mesh for lower 50 cm
- Optimize hydraulic parameters
- Forward calculation: 75 days from October 1, 2005
- Objective function: water content from 30 to 75 days

Initial and boundary conditions

- Initial condition

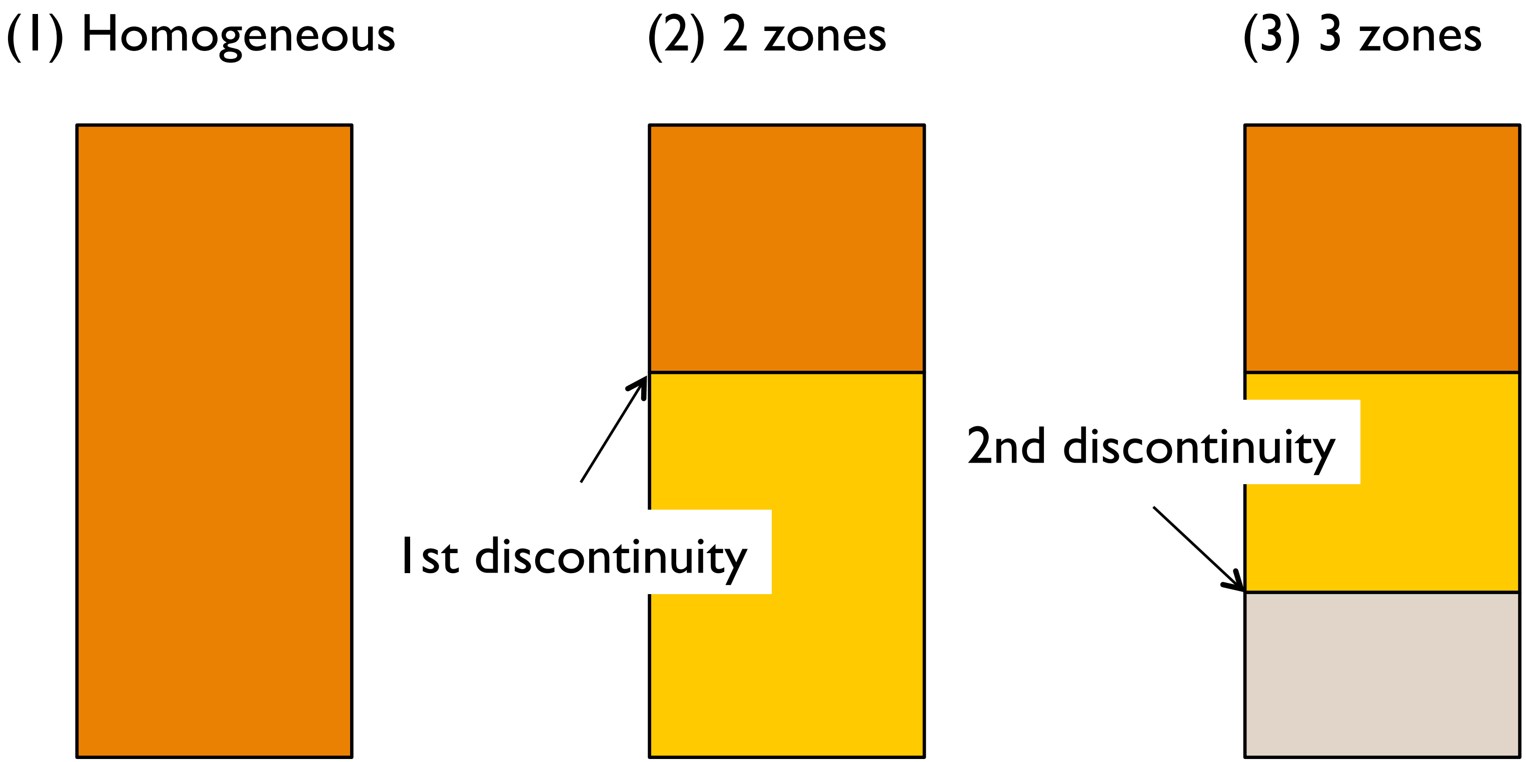
  Pressure head: -10000 cm
- Boundary condition
  - Upper boundary
    - Prescribed flux: Rainfall intensity and potential evaporation 3.7 mm/day (Penman-Monteith equation)
    - Minimum pressure head -10^5 cm
  - Lower boundary
    - Zero pressure gradient $\partial h / \partial z = 0$

Soil hydraulic model

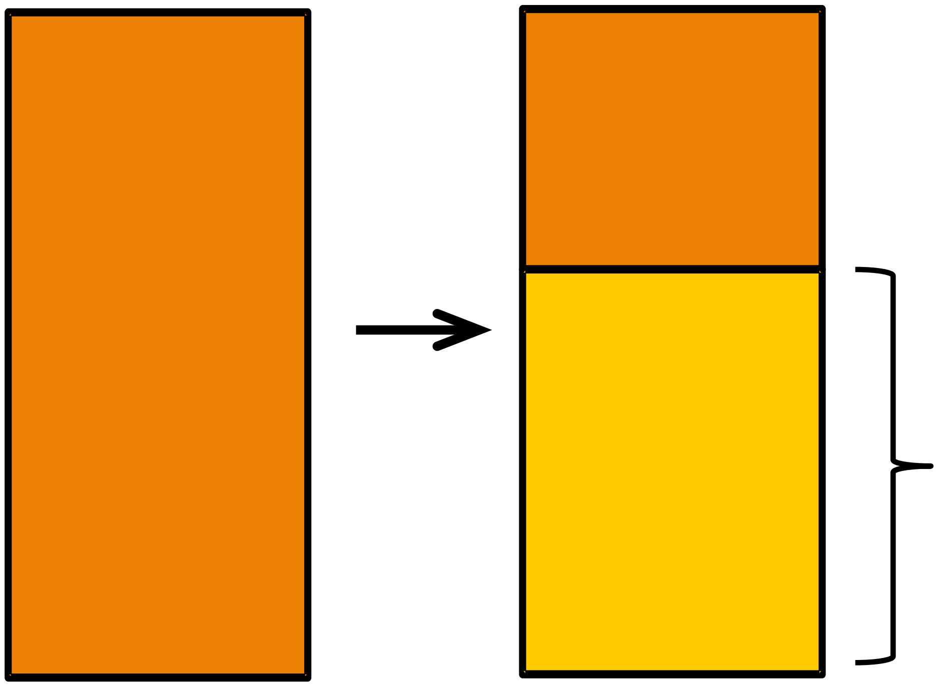
- Brooks and Corey – Mualem model
- Initial parameters: Measured with undisturbed core samples
- 4 initial parameter sets estimated from PTF (PedoTransfer Function) were also used for initial parameters.

Multi-scale parameterization method

(Hayek et al, 2008)



Calculation of refinement indicator to determine discontinuity depth



$$I = \left| \sum_{i \in Z_2} \frac{\partial O(p^{1*})}{\partial p_i} \right|$$

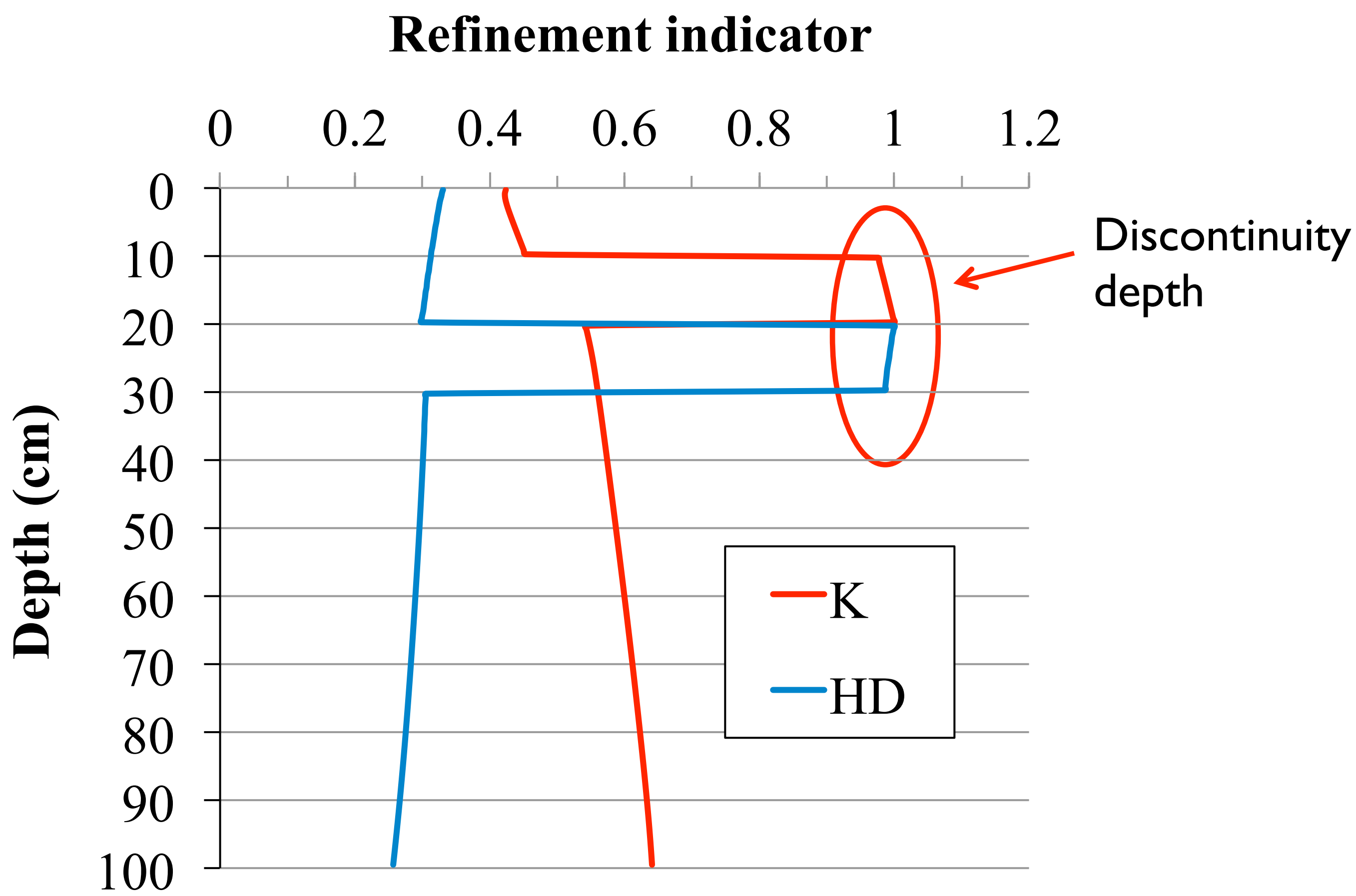
Sum of gradient of objective function to parameter

See Hayek et al. (2008) for definition

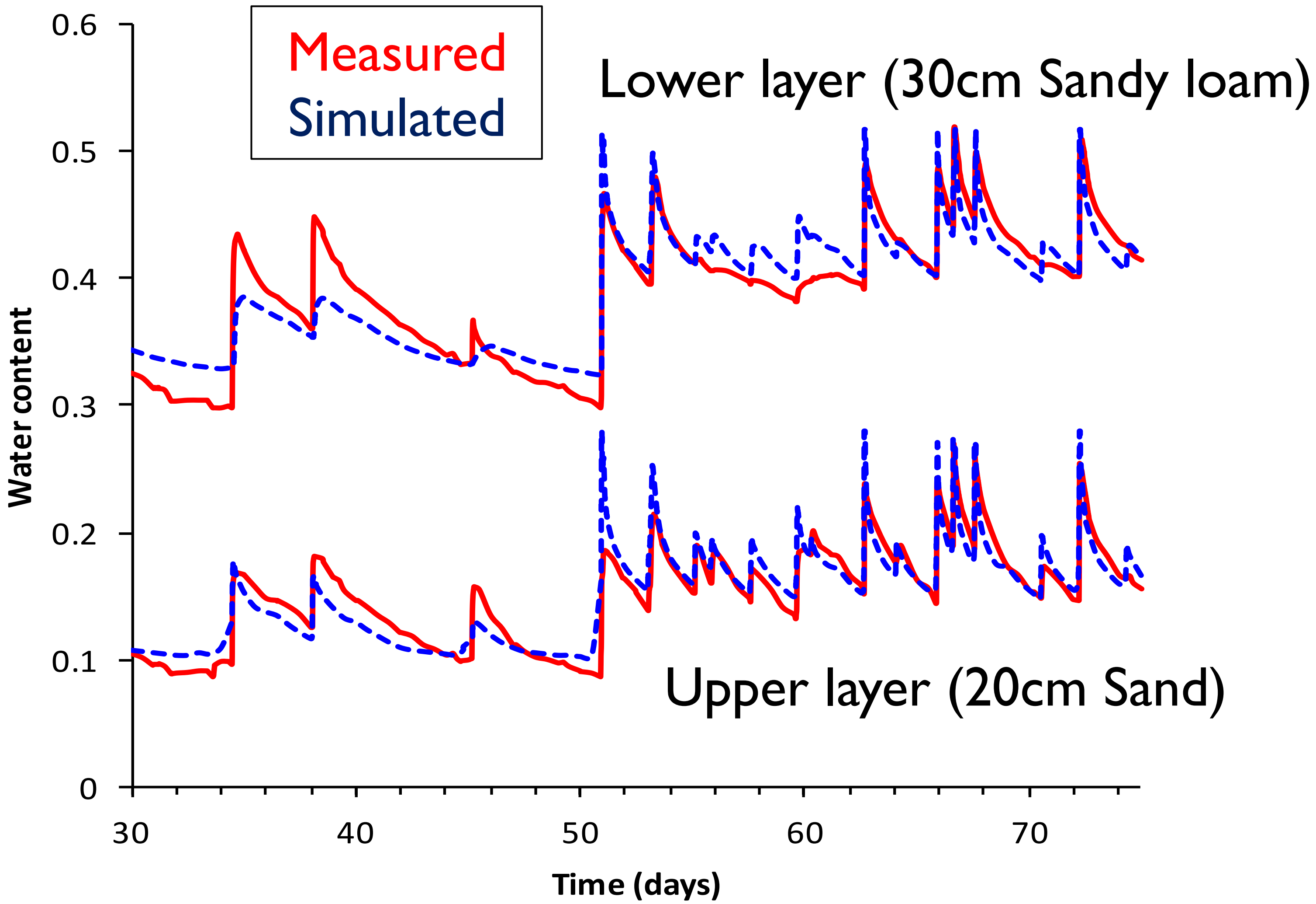
Modification to original algorithm

- Only soil moisture at one depth, upper layer, was used for homogeneous parameterization of HD plot, where soil texture was different at 2 depths.
- At each step of parameterization, refinement indicators of each parameter (Ks, θ s, θ r, α, n, λ) was used for determining the order of parameters to be optimized.

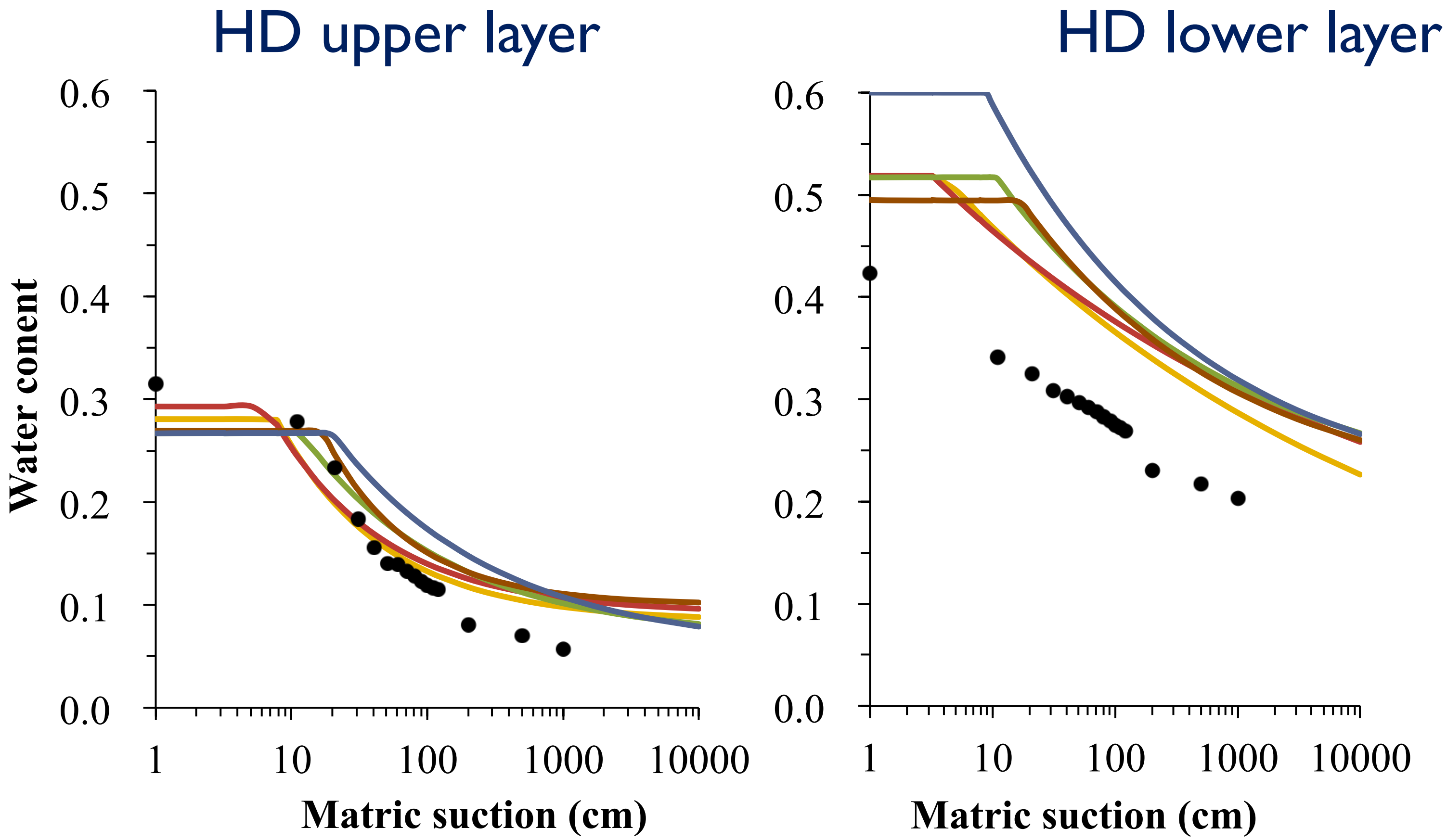
Refinement indicator



Measured and simulated water change
HD plot



Estimated and measured SWRC (soil water retention curve)

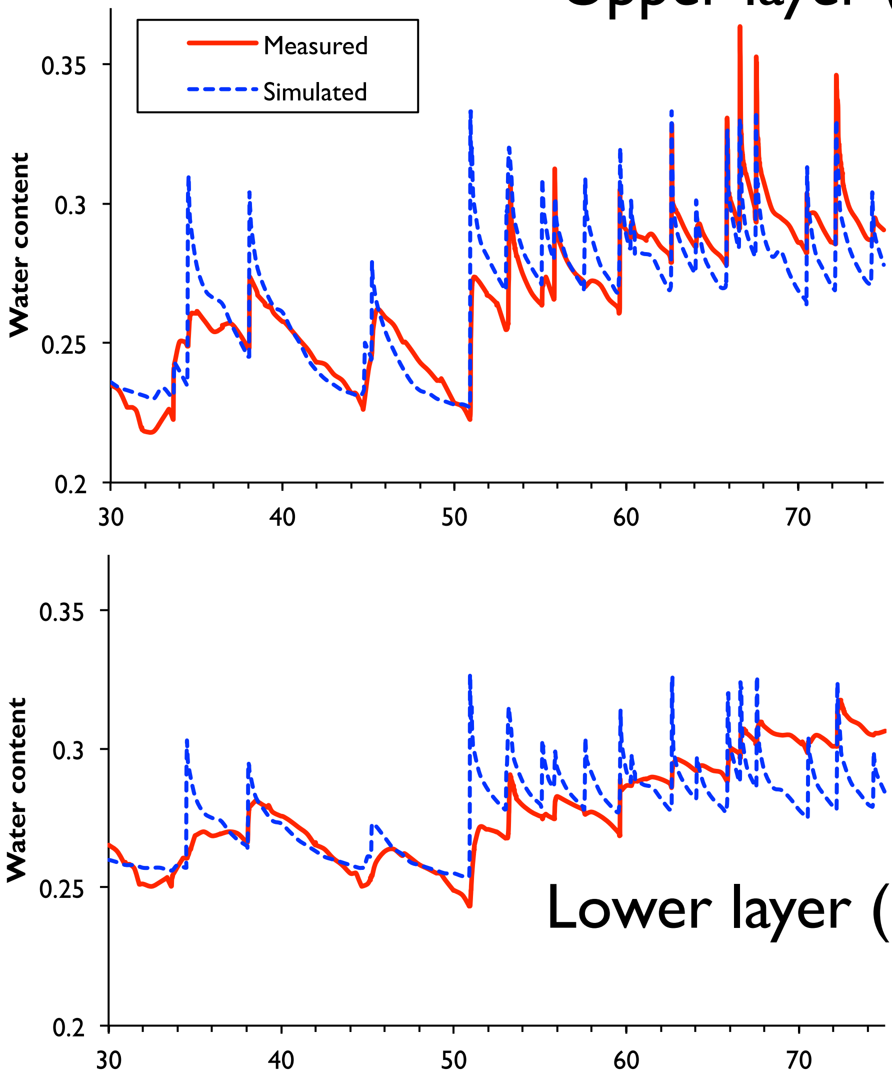


Robust for different initial parameters

Measured and simulated water change

K plot

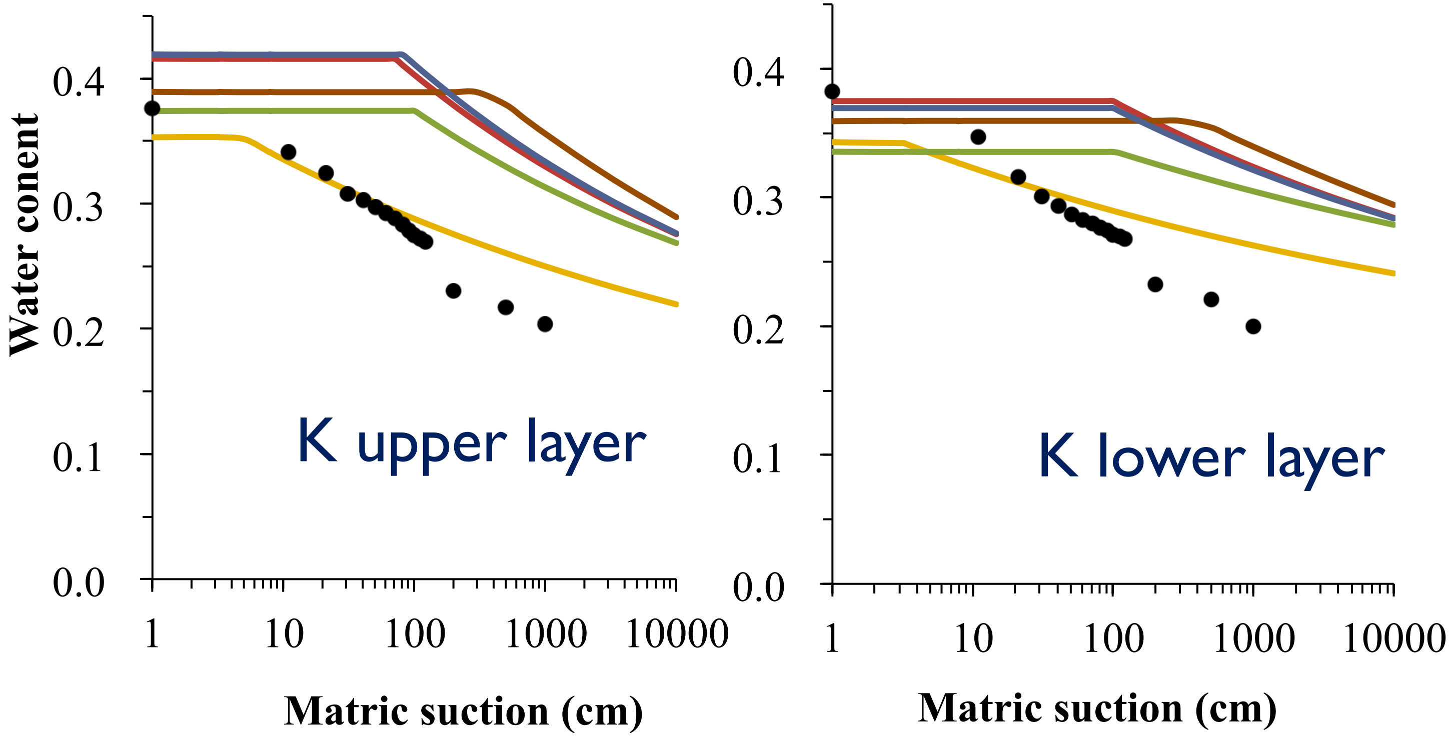
Upper layer (10cm)



Discrepancy

Lower layer (20cm)

Estimated and measured SWRC



Not as robust as HD plot

Possible reasons for discrepancy and uncertainty

- Non-uniform water flow due to water repellency
- Absense of pressure head measurement
- Effect of root uptake
- Effect of hysteresis in soil water retention
- Effect of precision of soil water sensor

Summary

- Estimated hydraulic parameters can simulate water contents in the field condition in the HD plot. The result was robust for different initial parameters.
- The result was not very good at K plot.
- When applying this method to other study area, uncertainty evaluation of the estimated parameters is recommended.