Improvement of CLM4 Soil Hydrology by Introducing Micropores/Macropores to the Soil/Aquifer Coupling

Zong-Liang Yang, Guo-Yue Niu, and Mingjie Shi

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Motivation

CLM soil moisture seasonal to interannual variability is weaker than observed.

Lawrence et al. (2011)
Water in the Soil Profile

Unsaturated zone (vadose zone)

Capillary Fringe: immediately above the water table
At the base, soil is saturated for all pores; at the top, saturation is limited to micropores.

Water Table

Saturated zone

www.earthdrx.org/poresizegwflow.html
Water in the Soil Profile

The soil pores are analogous to water pipes; small pore (small diameter pipe) $\rightarrow$ great rise.
How to compute the capillary fringe in CLM4?

Do we have distributions of micropores, mesopores, and macropores?

How to compute groundwater recharge in relation to soil/aquifer coupling?
A Simple Groundwater Model (SIMGM)

Water storage in an unconfined aquifer:

\[
dW_a \frac{dt}{dt} = Q - R_{sb} \]

\[
z_{\nabla} = \frac{W_a}{S_y} \]

Recharge Rate:

\[
Q = -K_a \frac{-z_{\nabla} - (\psi_{\text{bot}} - z_{\text{bot}})}{z_{\nabla} - z_{\text{bot}}} \]

\[
= K_a (1 + \frac{\psi_{\text{bot}}}{z_{\nabla} - z_{\text{bot}}} ) \]

Modified to consider micropore/macropore effects:

\[ C_{\text{mic}} \psi_{\text{bot}} \]

\[ C_{\text{mic}} \rightarrow \text{fraction of micropore content} \]

\[ 0-1 \quad (0 \text{ macropore} \rightarrow \text{free drainage}; \quad 1 \text{ micropore} \rightarrow \text{strong capillary rise}) \]

Niu et al. (2011)
Effects in the Noah LSM

Micropore fraction: $C_{\text{mic}} = 0.5$
Effects in CLM4SP

Illinois (37-44N, 94-86W)

Top 1m Soil Water (mm)

Top 2m Soil Water (mm)

Year

Year

OBS
SP
SP-MOD1
SP-MOD-8
SP-MOD_Y
Summary

Preliminary results show that a simple consideration of micropores/macropores in the soil/aquifer coupling enhances soil moisture variability.

More tests with observed data are warranted.