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Update on IP3 Soil Water Budget: Verification of a Revised Analytical Soil Moisture Parameterization Scheme

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Improved Processes & Parameterisation for Prediction in Cold Regions

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Background

•Richards' Equation represents the water movement in variably saturated soil columns but is not transparent or easy to use

•The proposed analytical solution provides a simple, fast, and robust soil moisture parameterization scheme

•The method is based on two asymptotic end states: saturated gravity dominated flow and unsaturated suction dominated flow

•Testing is in progress. Results have been successfully compared with field capacity measurement as well as numerical simulation results

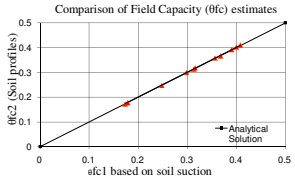
Field Capacity Comparison

Residual soil moisture is calculated by equation (1). It combines topographic and soil parameters.

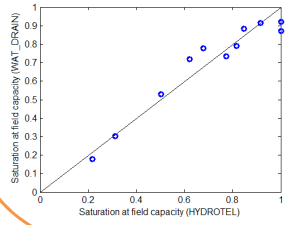
Topographic parameters: slope, length, and thickness

Soil parameters: slope, Hydraulic conductivity, air entry; pressure, porosity, and soil index

$$\bar{S}_{fc} = \frac{1}{(b-1)}\left(\frac{-\psi_a b}{L\Lambda}\right)^{1/b}\left[(3b+2)^{(b-1)/b} - (2b+2)^{(b-1)/b}\right] \qquad (1)$$



Equation (1) applied to Clapp and Hornberger (1978) data. The figure shows profile for 4ft vertical column versus soil suction = 1/3atm.



The figure shows the relationship between the saturation at field capacity obtained using above field capacity equation for a depth of z=50 cm (solid line), compared to the values used in HYDROTEL (dots). The coefficient of correlation is 0.9665.

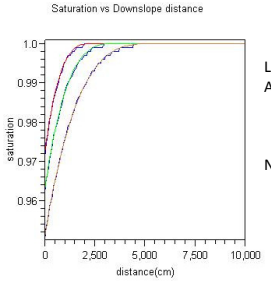
Numerical Solution Comparison

Saturated Gravity Dominated Flow

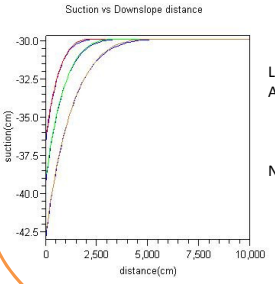
•Topographic parameters: slope=0.01, thickness=4m, and length=100m

•Soil Parameters: Hydraulic conductivity=6.30e-6m/s, air entry pressure=-0.299m, porosity=0.420, soil index=7.12

For 1, 2, and 3 months



Legend
Analytical solution:
Red-at t=2.0e6s
Green- at t=4.0e6s
Purple- at t=8.0e6
Numerical solution:
Blue- at the same time as analytical solution



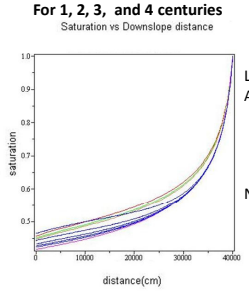
Legend
Analytical solution:
Red-at t=2.0e6s
Green- at t=4.0e6s
Purple- at t=8.0e6
Numerical solution:
Blue- at the same time as analytical solution

Unsaturated Suction Dominated Flow

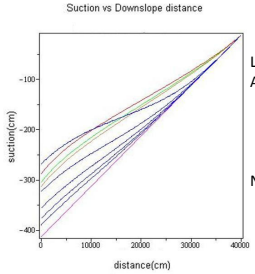
•Topographic parameters: slope=0.01, thickness=4m, and length=400m

•Soil Parameters: Hydraulic conductivity=1.76e-4m/s, air entry pressure=-0.121m, porosity=0.395, soil index=4.05

For 1, 2, 3, and 4 centuries



Legend
Analytical solution:
Red- at t=4e4 days
Green- at t=8e4 days
Gold- at t=1.2e5 days
Purple- at t=1.6e5 days
Numerical solution:
Blue- at same time as analytical solution



Legend
Analytical solution:
Red- at t=4e4 days
Green- at t=8e4 days
Gold- at t=1.2e5 days
Purple- at t=1.6e5 days
Numerical solution:
Blue- at same time as analytical solution

Conclusions

•Analytic solution matches numerical solution in detail for wet soil and on average for dry soil.

•The model accurately predicts field capacity and incorporates samples with topography.

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