Potential for Linking Saturated Hydraulic Conductivity and Quantitative Characterization of Soil Architecture at NEON Field Sites

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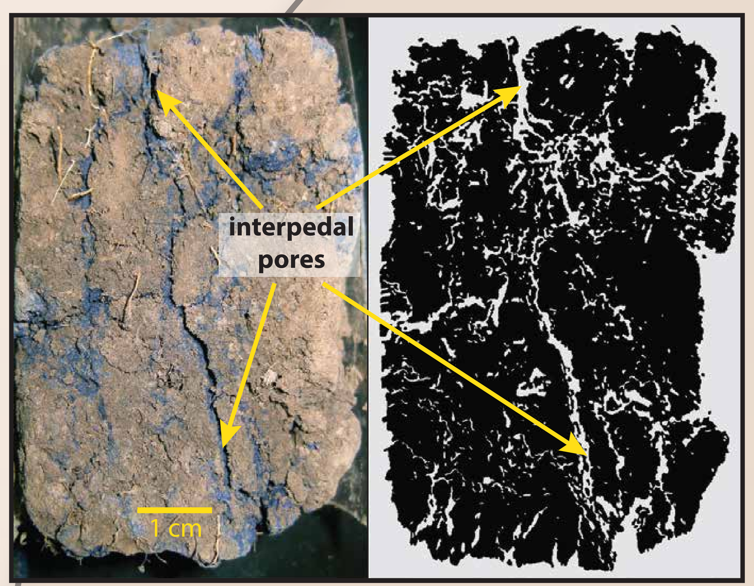
We tested a new 3-D laser scanning technique to measure the widths of interaggregate pores in an excavation wall and related those quantities to saturated hydraulic conductivities, K_s, estimated from a Markov chain Monte Carlo (MCMC) algorithm. We propose there is a need for a similar approach at NEON field sites in order to inform and enhance continental-scale modeling of ecohydrological and land-atmospheric processes.

1a. Soil Architecture

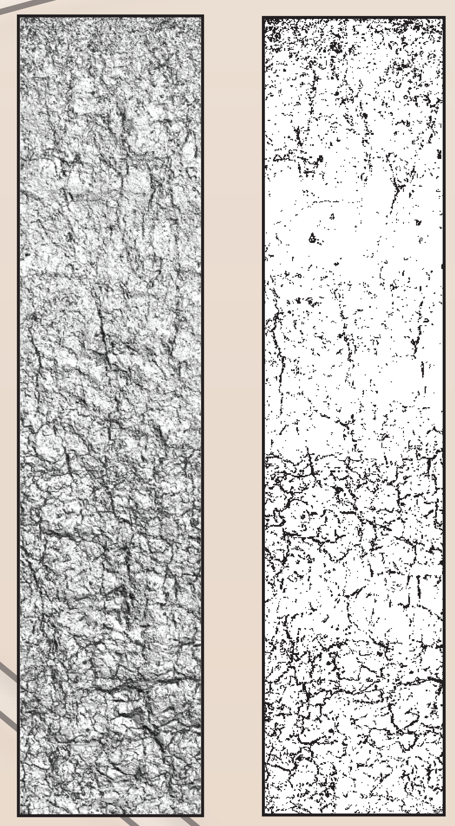
A pit was dug in northeastern Kansas adjacent to an intact soil lysimeter where soil moisture and atmospheric variables were measured. The excavation wall was frozen with 1,1-difluoroethane to remove artifacts (Hirmas 2013) and scanned with a multistripe laser triangulation (MLT) scanner (Eck et al. 2013).



Initial dye studies using methylene blue indicated that missing data from the MLT scan could be used to measure interaggregate pores, thus quantifying the 2-D soil architecture.

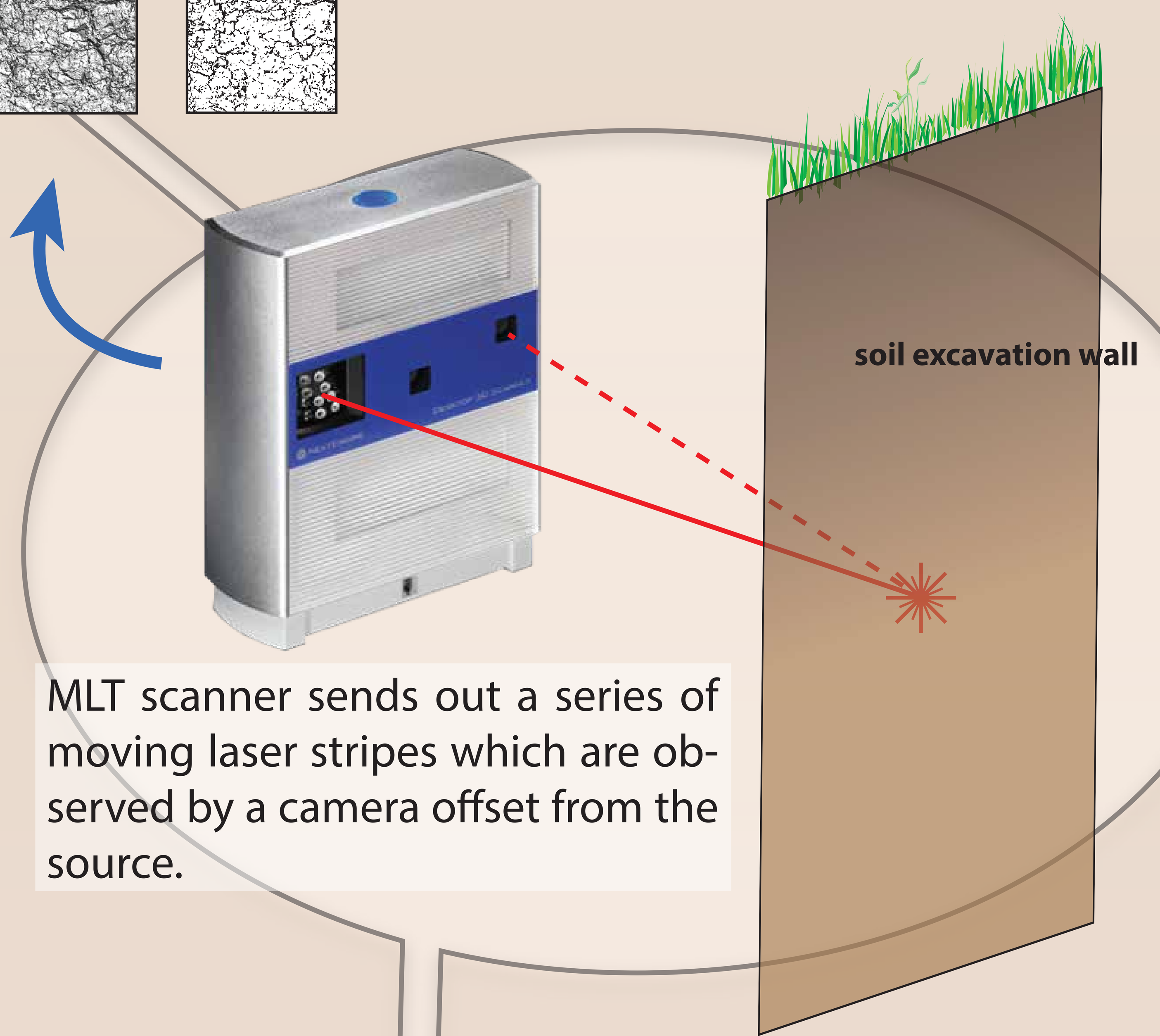
Scanned Profile

Binarized Interaggregate Pore Profile



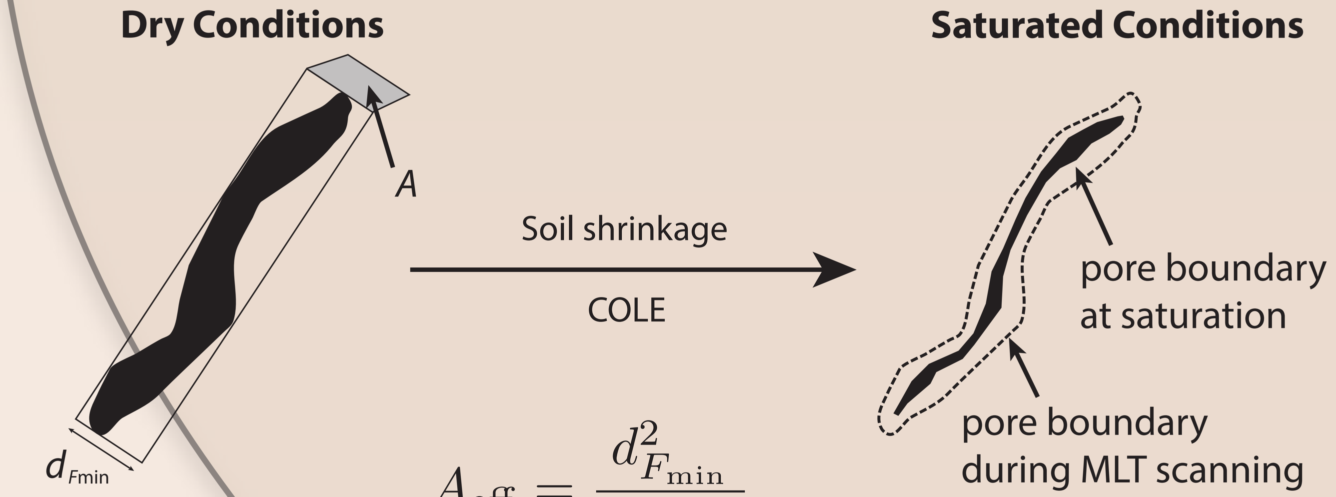
NEON Konza Core Site

NEON KU Field Station Relocatable Site



MLT scanner sends out a series of moving laser stripes which are observed by a camera offset from the source.

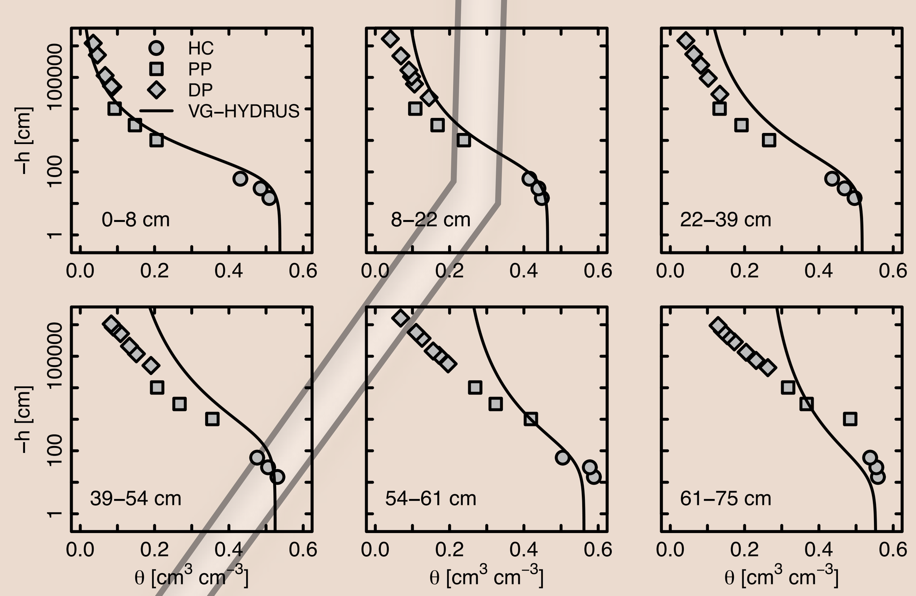
1b. Effective Pore Area



$$A_{\text{eff}} = \frac{d^2_{F_{\min}}}{\text{COLE}}$$

Water retention was measured from each of 6 horizons at the site and used to inform the MCMC approach by which K_s was estimated. Precipitation, PET, and soil moisture at 4 depths was recorded at 0.5 hr time steps for a 10-day period and used as inputs for the model.

2. Measurements



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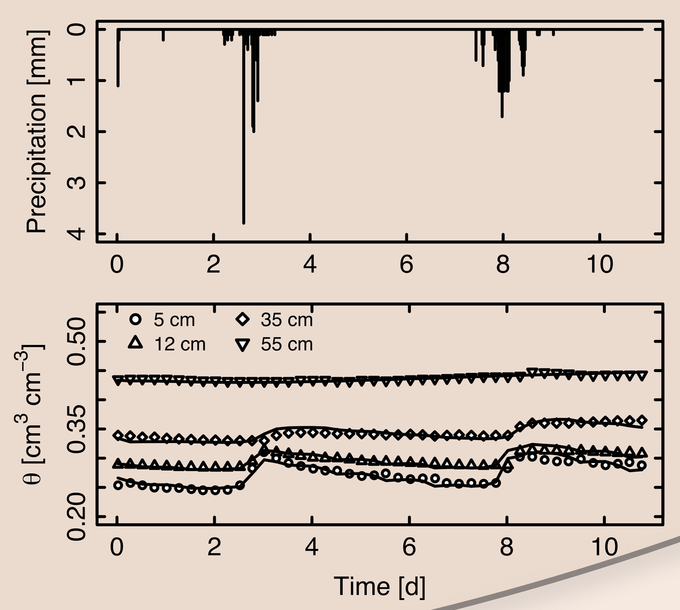

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3. HYDRUS-1D + DREAM(ZS)

Soil-Water Continuity Equation:

$$\frac{\partial \theta(h)}{\partial t} = \frac{\partial}{\partial z}\left[K(h)\frac{\partial h}{\partial z}\right] + \frac{\partial K(h)}{\partial z} - S(h)$$

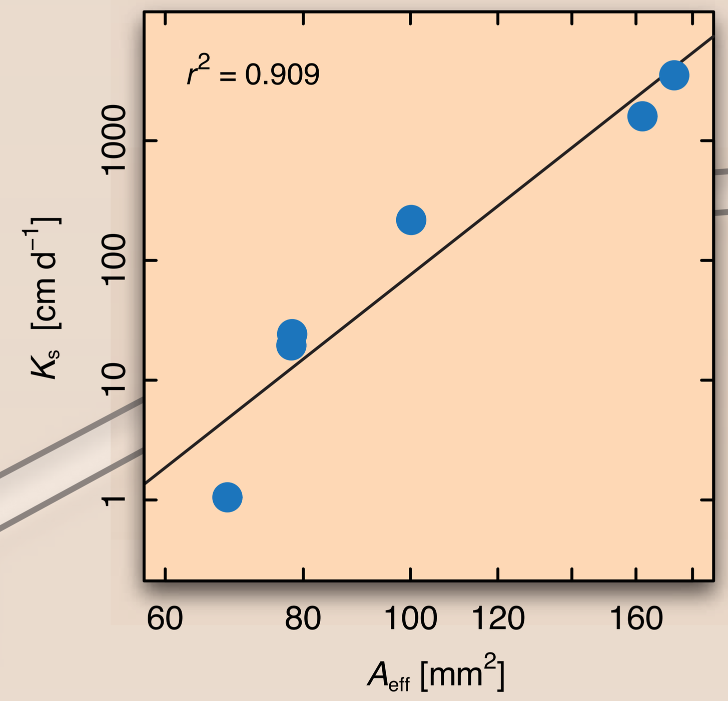
van Genuchten Water Retention Function:

$$S_e(h) = \frac{\theta - \theta_r}{\theta_s - \theta_r} = [1 + (-\alpha h)^n]^{-m}$$

Unsaturated Hydraulic Conductivity Function:

$$K(S_e) = K_s S_e^l \left[1 - \left(1 - S_e^{\frac{1}{m}}\right)^m\right]^2$$

4. Results



The interaggregate pores appear to be a good predictor of K_s in the strongly-structured soil used in this study.

5. Potential for NEON

We have scanned in high-resolution (120 µm) three 2-m soil pits at the Konza Core and Relocatable sites. One of the relocatable sites (KU Field Station) was instrumented with soil moisture and potential probes. We argue that similar soil architecture measurements should be made at other NEON sites and that water retention and soil water potential measurements are needed to fully model soil water dynamics.

Acknowledgements

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References

Eck et al. 2013: [SSSAJ 77:1319-1328]
Hirmas 2013: [SSSAJ 77:591–593]