

Why (and how) to determine soil water retention curves for Ameriflux sites

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What is a soil water retention curve?

• Soil moisture:

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- How much water is in the soil?
- Units: Volume fraction or mass
- Soil water potential:
 - How tightly is water held by soil?
 - Units: Pressure or energy density
- Water retention curve describes the relationship between soil moisture and soil water potential



Miller et al. (2006, Adv. Water Res.)



Wetter soil: Water is easy to pull out of pores

Drier soil: Remaining water is more tightly held

Wolf et al., PLoS ONE, 2013

Why is this important?



Soil water retention curves for Ameriflux sites

Water potential is also important for microbial physiology and decomposition $(\phi-\theta)/\phi$



CAK RIDGE National Laboratory Soil water potential affects microbial physiology as soils get very dry

Combined model includes both effects.

Ghezzehei et al., in review, Biogeosciences (https://www.biogeosciences-discuss.net/bg-2018-265/) Soil water retention curves for Ameriflux sites Can't we just fit nonlinear functions for each site? The problem: Water retention curves change with soil properties. Cross-site comparisons become problematic



ROSETTA/HYDRUS simulations (Jing Yan) ROSETTA: Schaap et al., 2001 HYDRUS: Simunek et al., 2005

Wolf et al., PLoS ONE, 2013

Water vapor fluxes vs. moisture 0.4 sand loamy sand Elux (cm/day) 0.2 0.1 sandy loam loam silt 0.2 clay loam silty clay loam clay **HYDRUS** simulations 0.0 0.2 0.1 0.3 Root zone moisture (vol. fraction)





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- silty clay loam
- 🗕 clay

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Water vapor fluxes vs. SWP



Relationship with water potential is more linear and has consistent change points (but does not work as well for sandy soils)

Changes with soil types: Soil respiration



ion curves for Ameriflux sites



Changes with soil types: Soil respiration

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on curves for Ameriflux sites



How can we estimate soil water retention curves?



Maybe we don't have to! Water retention curves are in BADM already!

Great, the job is done!



How many sites out of 355 in the all-site BADM data sheet provide water retention curve data?



(As far as I could find) Soil water retention curves for Ameriflux sites



The more expensive, more accurate way Laboratory measurements

Pressure plates

- Applies pressure to sample and squeezes out water held at less than that pressure
- Often used to calibrate secondary methods
- Time consuming: requires separate measurement for each point on curve and can require days per measurement

Dew point hydrometer

- Accurate from -5 -300 MPa
- 5-10 minute measurement time for most samples

HYPROP:

- Automated tensiometer measurements
- Wetter end of the curve



Photo by Landcare

Research

Disadvantage: Requires specialized equipment and expertise, and a series of delicate measurements for every site.



The cheaper, (probably) less accurate way

Field-calibrated pedotransfer functions and models

ROSETTA model (Schaap et al., 2001) Calculates pedotransfer functions at different levels of accuracy depending on data availability:

- Textural class (lookup table)
- Sand/silt/clay % (neural network)
- Sand/silt/clay + bulk density
- Sand/silt/clay, BD, SOM content

Many sites do report these soil properties in BADM!

Disadvantage: Fundamentally a model-based approach. May be inaccurate at site-specific level.



Fig. 7. Water retention data for 47 loam samples (totaling 412 points) with a bulk density range between 1.3 and 1.4 g cm^{-3} . The curve represents the estimation with model H3.





What is the best path forward?

- I hope I have convinced you that determining water retention curves is **worth the trouble**
- Quick, low investment, lower accuracy:
 - Use ROSETTA model and BADM soil properties to estimate curves
 - These could be released as an ancillary Ameriflux network dataset
- Long-term, higher investment, high accuracy:
 - Measure soil water retention curves in the laboratory as part of Ameriflux Management Project site support
 - Could require new equipment and expertise
 - High potential benefit for cross-site comparisons and scientific community

What do you think?



