Constructing Fast, Accurate Soil Water Characteristic Curves by Combining the Wind/Schindler and Vapor Pressure Techniques

Leo Rivera[1], Doug Cobos[1,2], Gaylon Campbell[1]
[1] Decagon Devices, Inc.
[2] Washington State University Department of Crop and Soil Sciences

Introduction

- No single instrument can measure full water potential range (wet to dry)
- Pressure plates often used from 0 to -1500 kPa, but errors at wet end (Or and Tuller 2002, Baker and Frydman 2009) and dry end (Gee et al. 2002, Bittelli and Flury 2008) call accuracy into question
- Tensiometers often used in wet end and vapor equilibration techniques (psychrometer, dew point hygrometer) used in dry end
- In past, gap existed between tensiometer range (0 to -100 kPa) and vapor equilibrium range (about -500 to -300,000 kPa)
- Improvements to vapor equilibrium instrumentation have pushed measurement range further into wet end
- New automated SMCC instruments using Wind/Schindler (Schindler and Muller 2006) method (based on tensiometry) give unparalleled accuracy and resolution in wet end

- Question # 1: Do vapor equilibrium measurements match tensiometer measurements in wet region of SMCC?
- Question #2: Can new Wind/Schindler instrumentation be used in conjunction with vapor equilibrium methods for full range SMCC?

Methods

- SMCCs were generated on 5 different soils over a wide range of soil texture and mineralogy (Table 1, lower right corner of poster)
- Volcanic Hanipoe Silt Loam soil SMCCs generated with tensiometers (T5, UMS Gmbh) in the wet region and chilled mirror dew point hygrometer (WP4C, Decagon Devices, Figure 1) in dry region. All Hanipoe samples were wet up from air dry and therefore on the wetting leg of hysteresis loop
- Fine Sandy Loam and Loamy Fine Sand SMCCs were generated with an automated Wind/Schindler device (Hyprop, UMS Gmbh, Figure 1) in the wet region and the WP4C in the dry region. The Hyprop starts with a saturated sample and generates the SMCC as the soil dries, while the WP4C samples were wet up from air dry, putting the wet and dry segments of the SMCC on different legs of the hysteresis loop
- The Palouse Silt Loam SMCC was generated with Hyprop in the wet region and WP4C at the dry region. WP4C samples were collected as intact cores and either wet up or dried down from field conditions (~-150 kPa), so WP4C samples wetter than -150 kPa are on the wetting leg and samples drier than -150 kPa are on the drying leg of the hysteresis loop

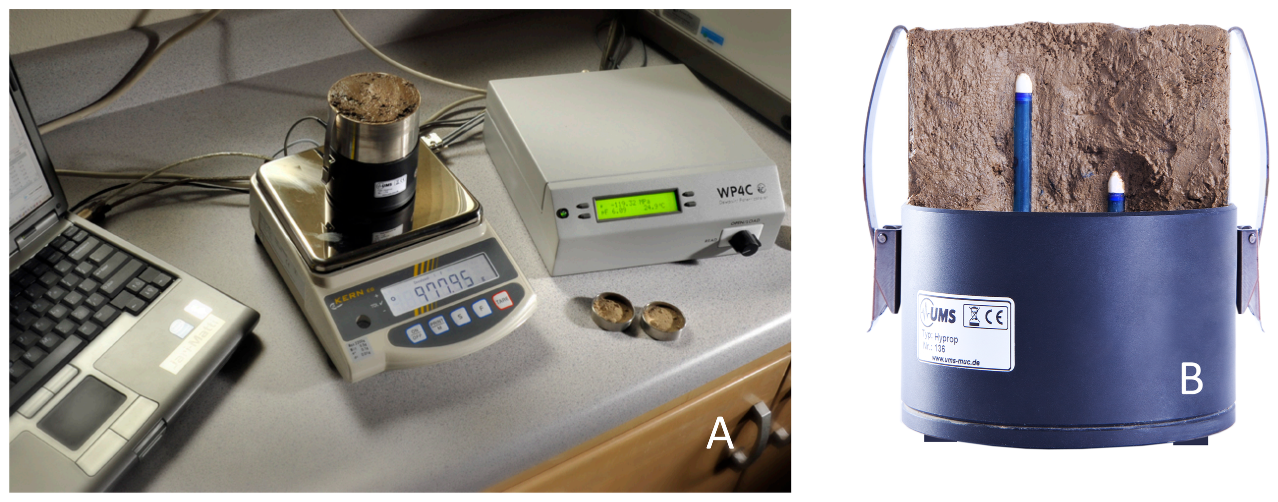

Figure 1. A.) Instrumentation used in this study. Hyprop automated SMCC generator from UMS (center) and WP4C dewpoint hygrometer from Decagon (right). B.) Cutout of the HyProp showing placement of the two tensiometers in the soil.

Contributing author contact information
Leo Rivera
Decagon Devices
+1 (509) 332-2756
leo@decagon.com

Results

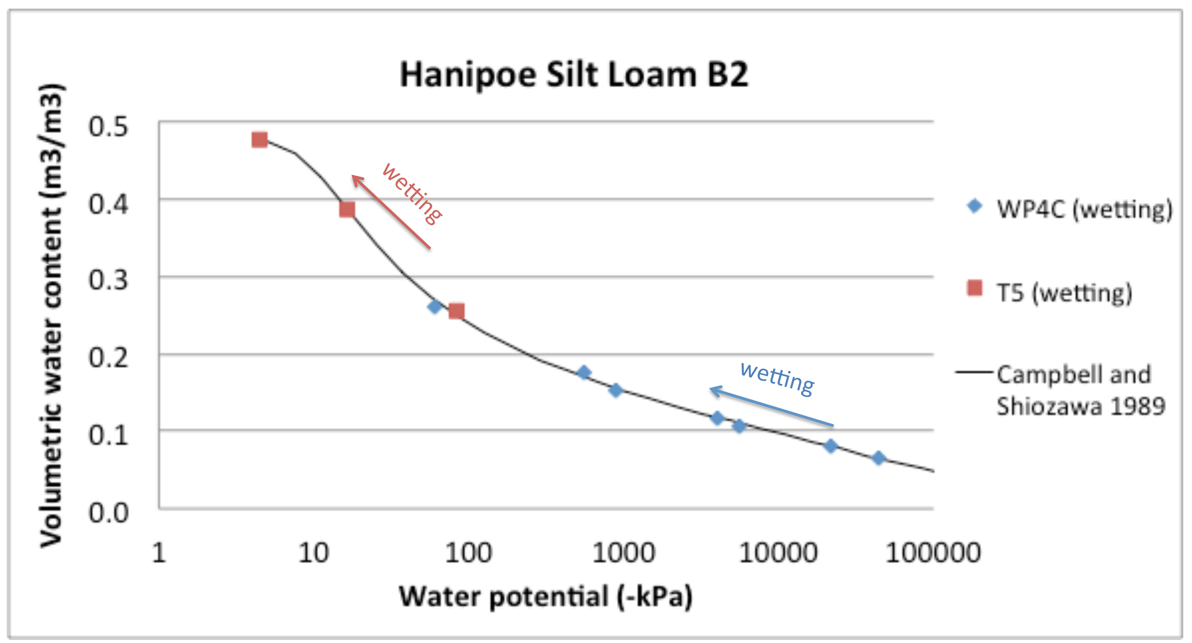

Figure 2. SMCC for volcanic Hanipoe Silt Loam B2. Note crossover between tensiometer and WP4C portions of SMCC due to both sets of samples falling on the wetting leg of hysteresis loop

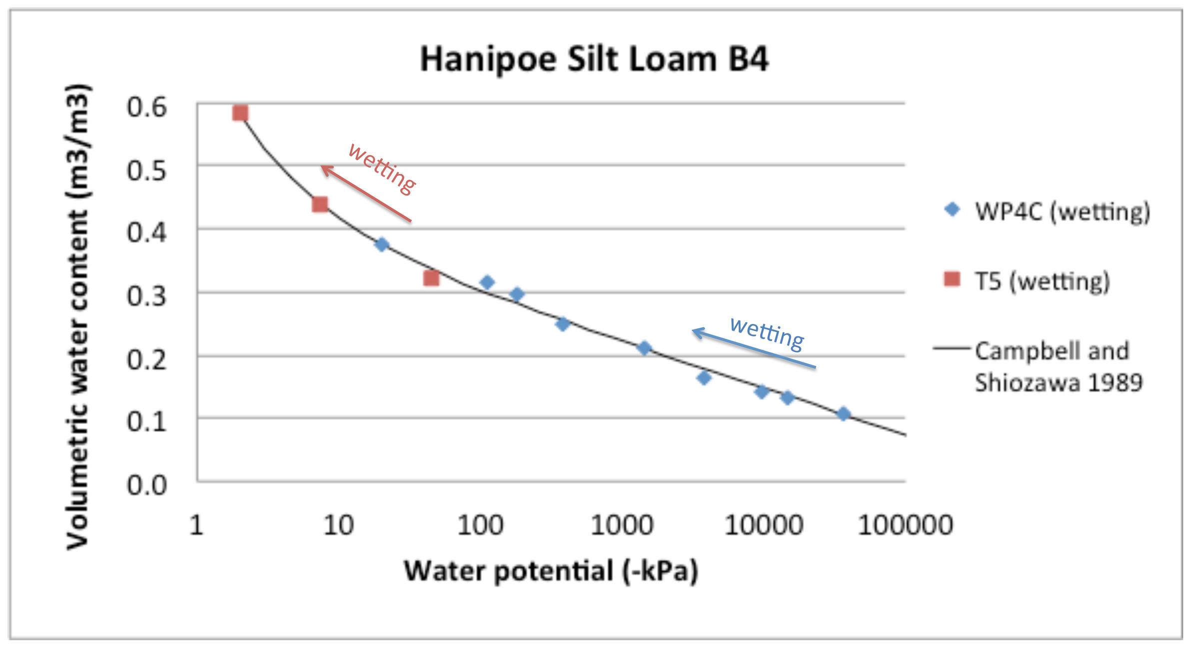

Figure 3. SMCC for volcanic Hanipoe Silt Loam B4. Note crossover between tensiometer and WP4C portions of SMCC similar to Figure 2

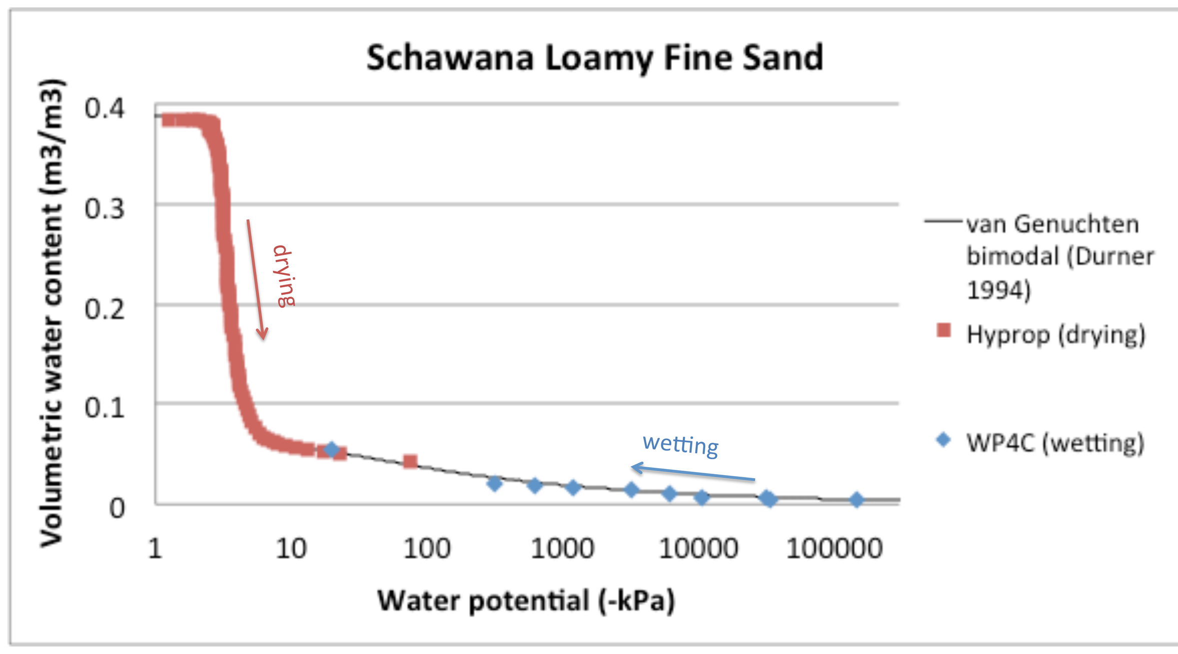

Figure 4. SMCC for Loamy Fine Sand. Note crossover between Hyprop and WP4C portions of SMCC *despite* samples falling on different legs of hysteresis loop which is made possible by low clay content of this soil

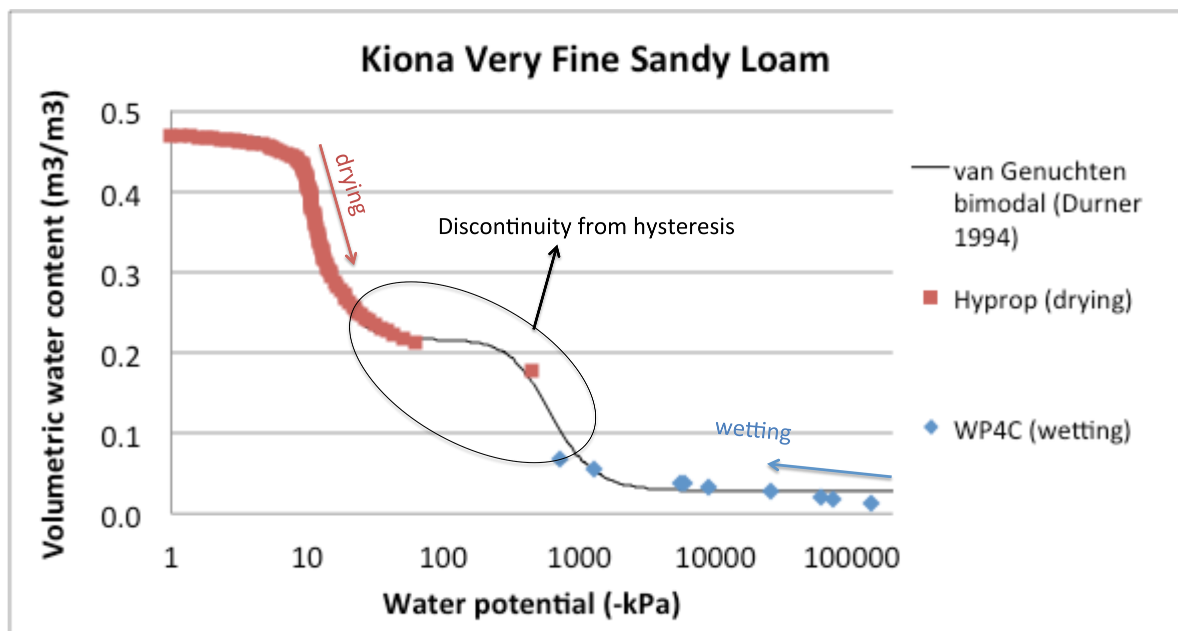

Figure 5. SMCC for Fine Sandy Loam. Note discontinuity between Hyprop and WP4C portions of SMCC caused by samples of a soil with significant clay fraction falling on different legs of hysteresis loop

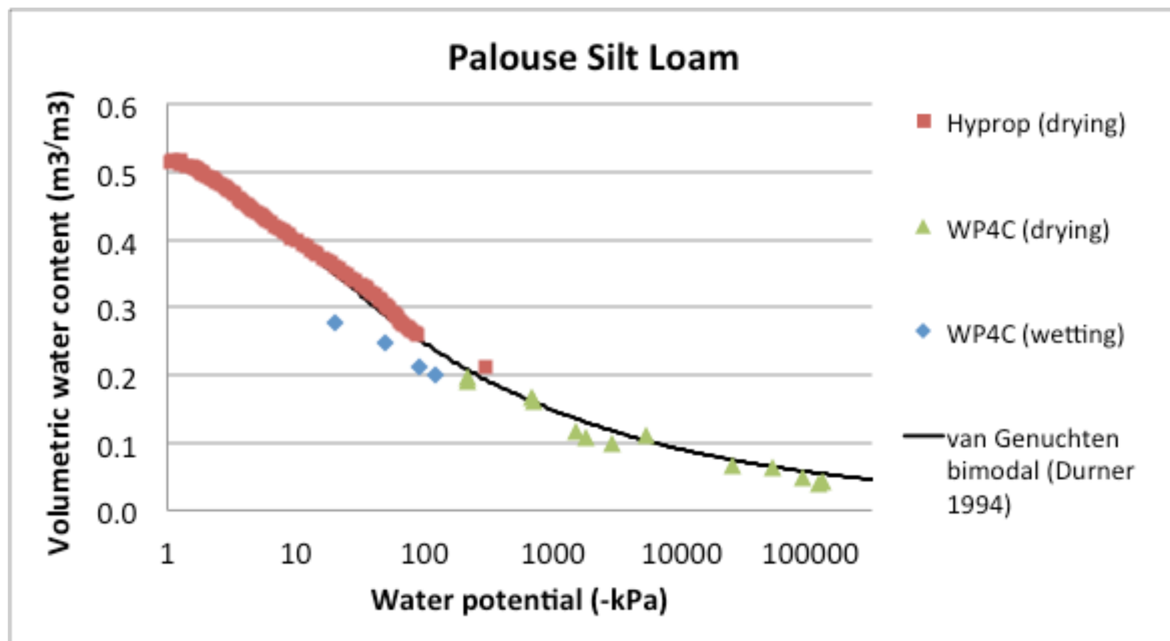

Figure 6. SMCC for Palouse Silt Loam. WP4C samples on drying leg of hysteresis loop match Hyprop data well, but WP4C samples on wetting leg of hysteresis loop deviate from Hyprop data

Discussion

- Tensiometer and WP4C measurements showed perfect crossover in both volcanic Hanipoe Silt Loam soils with all samples on wetting leg of hysteresis loop
- Hyprop and WP4C measurements showed perfect crossover in Loamy Fine Sand despite Hyprop measurements on drying leg and WP4C measurements on wetting leg. The lack of hysteresis is likely due to very low clay content.
- Significant offset between Hyprop and WP4C measurements in Fine Sandy Loam due to hysteresis effects (Hyprop on drying leg, WP4C on wetting leg)
- Hyprop measurements in Palouse Silt Loam agreed well with WP4C measurements drier than -150 kPa because all are on the drying leg of hysteresis loop. Some deviation was apparent in WP4C measurements wetter than -150 kPa as these samples lie on the wetting leg of hysteresis loop.

Summary

- Improvements in vapor equilibrium instruments (WP4C) allow measurements to push much further into wet range than previously possible
- The data in this poster are the first to show crossover of vapor equilibrium SMCCs into tensiometer range
- To link up tensiometer/Hyprop and WP4C generated SMCCs all samples should be on same leg of the hysteresis loop if there is significant clay fraction in the samples
- Further research necessary to determine effect of sample disturbance on wet region SMCCs from WP4C

Table 1. Physical properties of test soils.

	†Sand %	†Clay %	†Silt %	†$\rho_{b\ (1/3\ bar)}$ Mg m^{-3}	*w* (-1500 kPa) g g^{-1}
Kiona Very Fine Sandy Loam	64.4	10	25.6	1.59	0.05
Schawana Loamy Fine Sand	79.4	4	16.6	1.5	0.03
Palouse Silt Loam	67.7	21	11.3	1.2	0.07
Hanipoe Silt Loam B2	*	*	*	0.52	0.14
Hanipoe Silt Loam B4	*	*	*	0.61	0.21

* unavailable

†, values from published NRCS soil surveys

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