Estimating Water Retention Curves Between Measured Depths

Brad Illston

Research Associate

Oklahoma Mesonet

Scientific Question

- “If you have soil water retention curve parameters at two depths, can you estimate the parameters at a depth in between?”

Soil Moisture Sensors

- Oklahoma Mesonet soil moisture data (CS 229-L)
- 5cm and 25cm existed, added 10cm in 2012-13
- Original cores take in 2010 and then newer stations in 2014-15

Soil Matric Potential

$$MP = -c \cdot \exp(a \cdot \Delta T_{ref})$$

- MP = soil matric potential (kPa)
- WT = soil water tension (kPa)
- a = calibration constant (1.788 $^{o}C^{-1}$)
- c = calibration constant (0.717 kPa)
- ΔT_{ref} = reference temperature differential (°C)

Estimation of Soil Water Content

$$WC = WC_r + \frac{WC_s - WC_r}{\left(1 + \left(-a \cdot MP\right)^n\right)^{\left(1-\frac{1}{n}\right)}}$$

- MP in kPa
- van Genuchten (1980)

Empirical Coefficients:

- α = empirical constant (kPa^{-1}) – scale parameter
- n = empirical constant (unitless) – shape parameter
- WC_r = residual water content (cm^3_{water} / cm^3_{soil})
- WC_s = saturated water content (cm^3_{water} /cm^3_{soil})
- Arya and Paris, 1981

Matlab Functions

- Assumption: Pseudo-linear change between depths

- Soil Physics Toolbox
- http://soilphysics.okstate.edu/soil-physics-toolbox
- SWRCfit.m

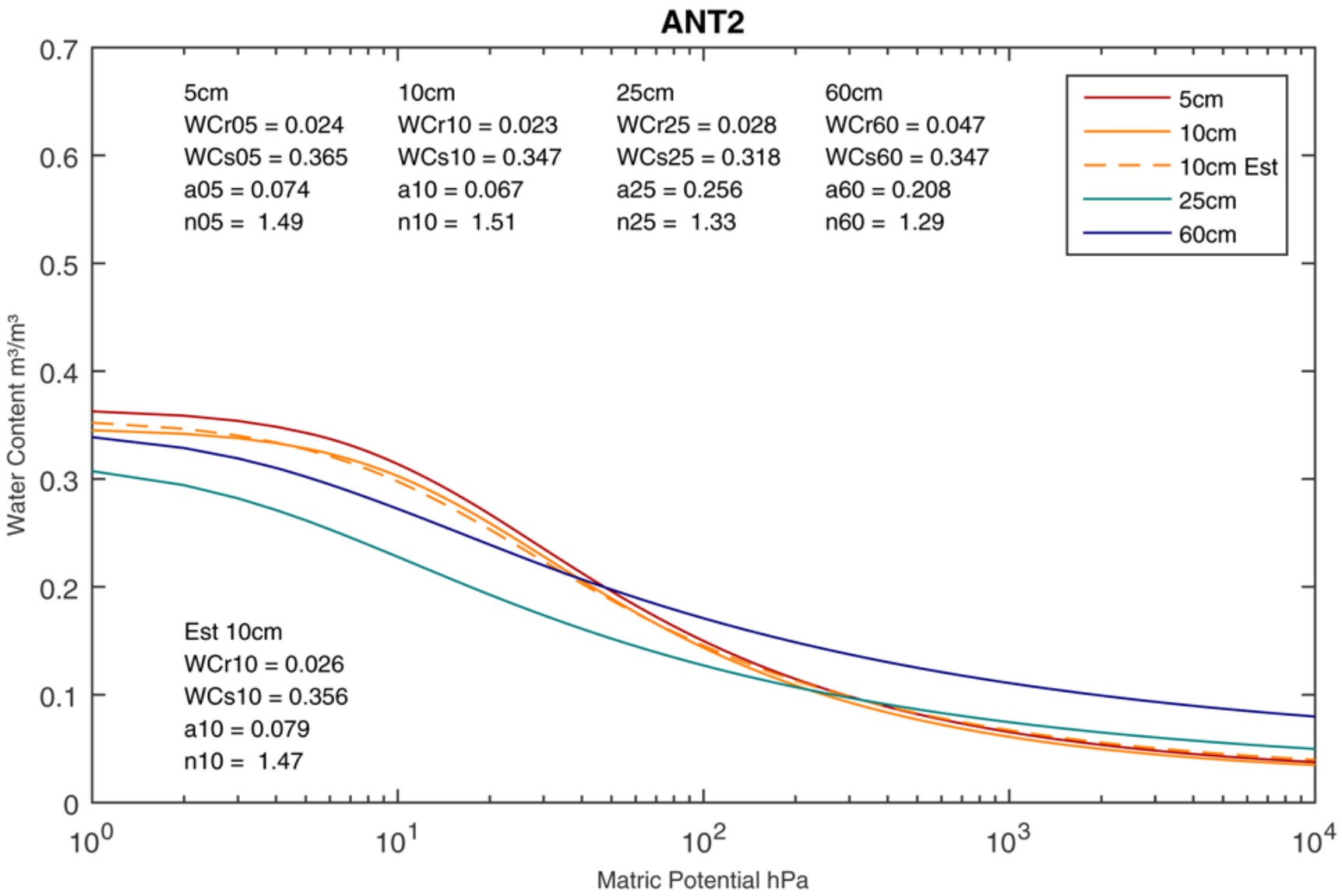
- LSQCurve Fit
- http://www.mathworks.com/help/optim/ug/lsqcurvefit.html?refresh=true
- Solve nonlinear curve-fitting (data-fitting) problems in least-squares sense

van Genuchten model

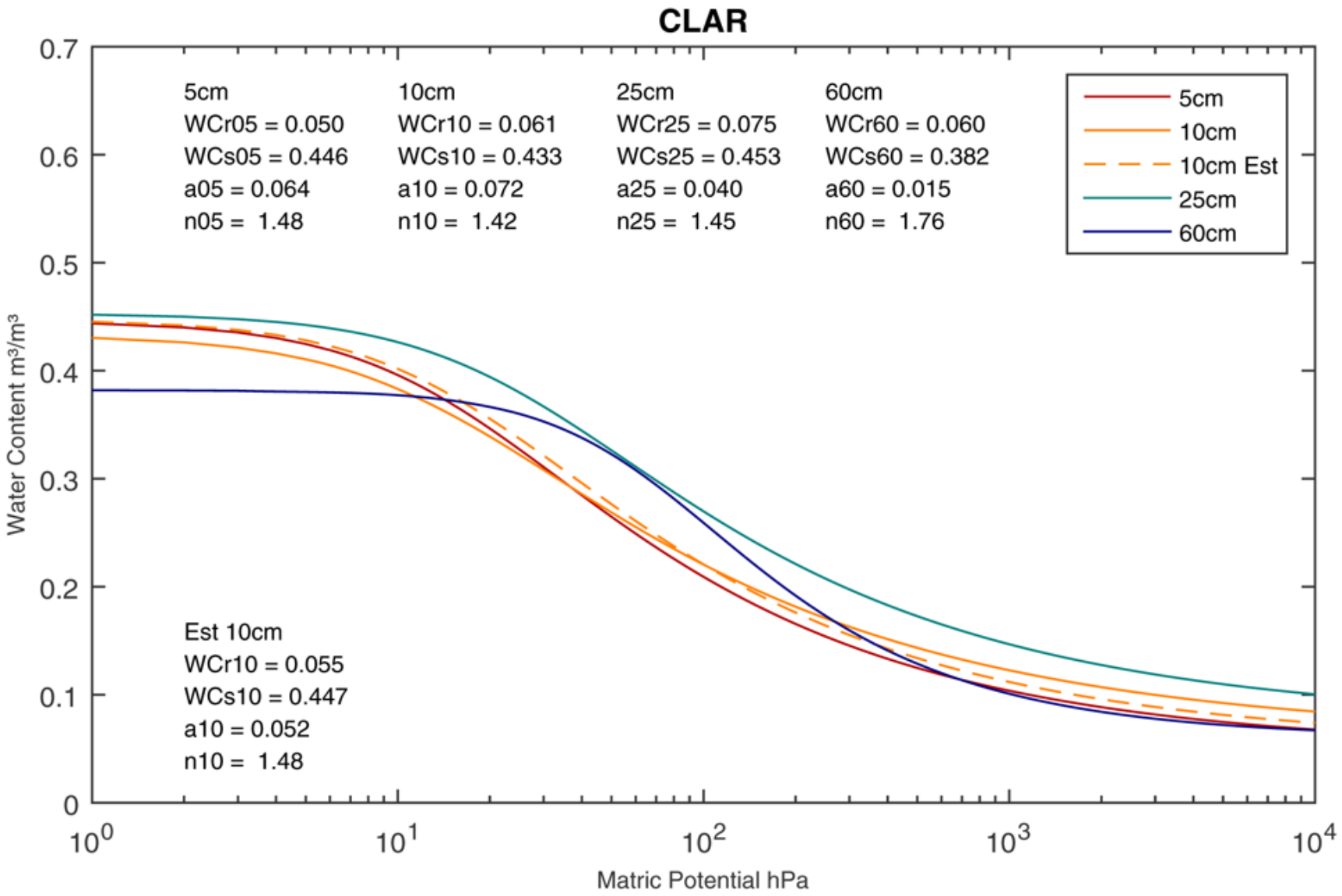
```
% * van Genuchten model
%
% vGx = van Genuchten fitting parameters (Model by van Genuchten, 1980)
%
%       vGx(1) = alpha (inverse of bubbling pressure) [1/cm or 1/kPa]
%       vGx(2) = theta_r [cm3/cm3]
%       vGx(3) = n (related to pore size distribution)


MP=0:1:10000;
wc10est = (10-5)*(wc25-wc05)./(25-5) + wc05;
vGmodel = @(vGx,h) (1./(1+(vGx(1)*MP).^vGx(3) )).^(1-1/vGx(3)) *(wc10est(1)-vGx(2))+vGx(2);
vGx0=[0.03;0.08; 1.5];
options = optimset('Display','off');
[vGx] = lsqcurvefit(vGmodel,vGx0,MP,wc10est,0,10, options);
stats=sprintf('Est 10cm\nWCr10 = %5.3f\nWCs10 = %5.3f\na10 = %5.3f\nn10 = %5.2f', vGx(2), wc10est(1), vGx(1),
vGx(3));
```

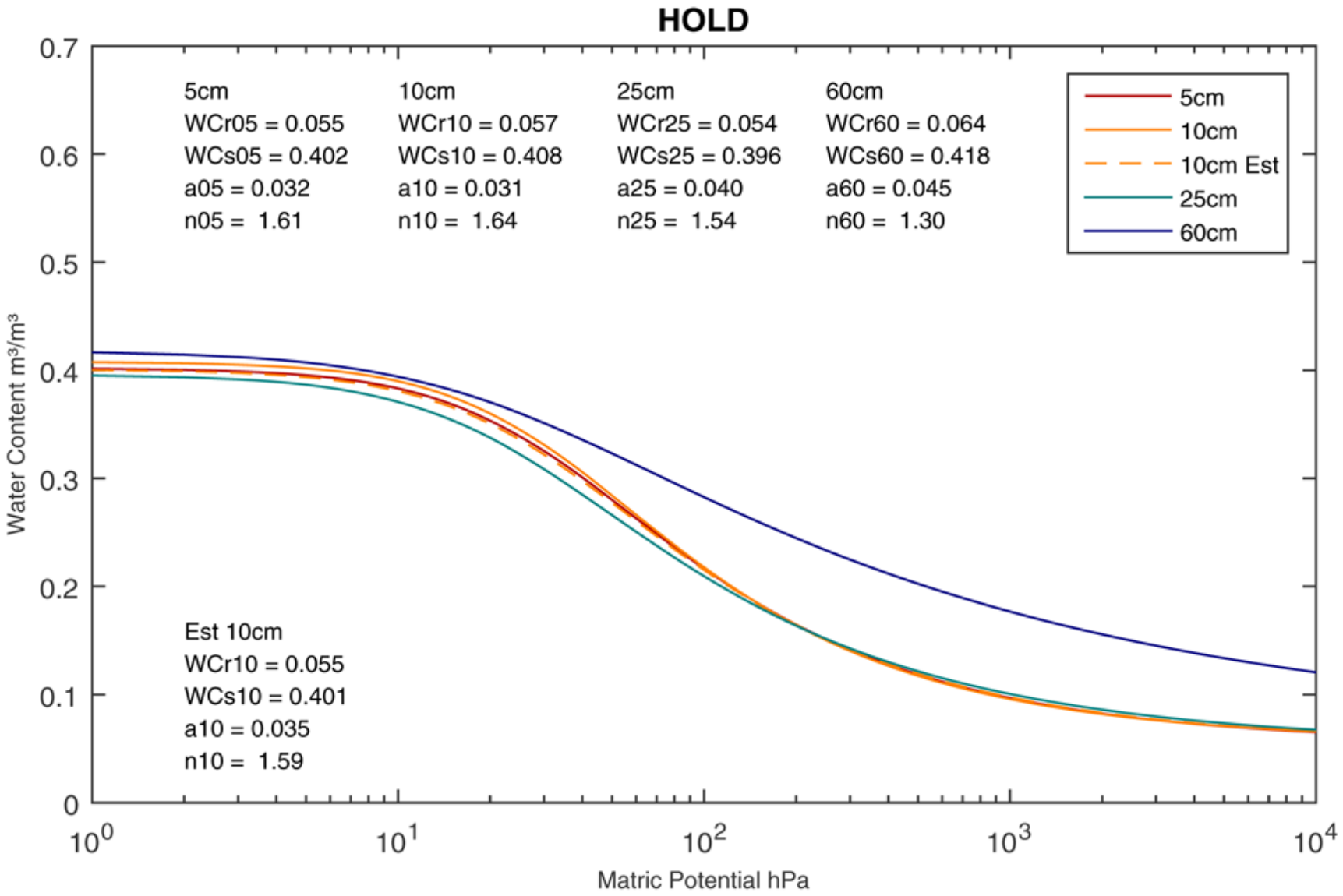
Good Matches



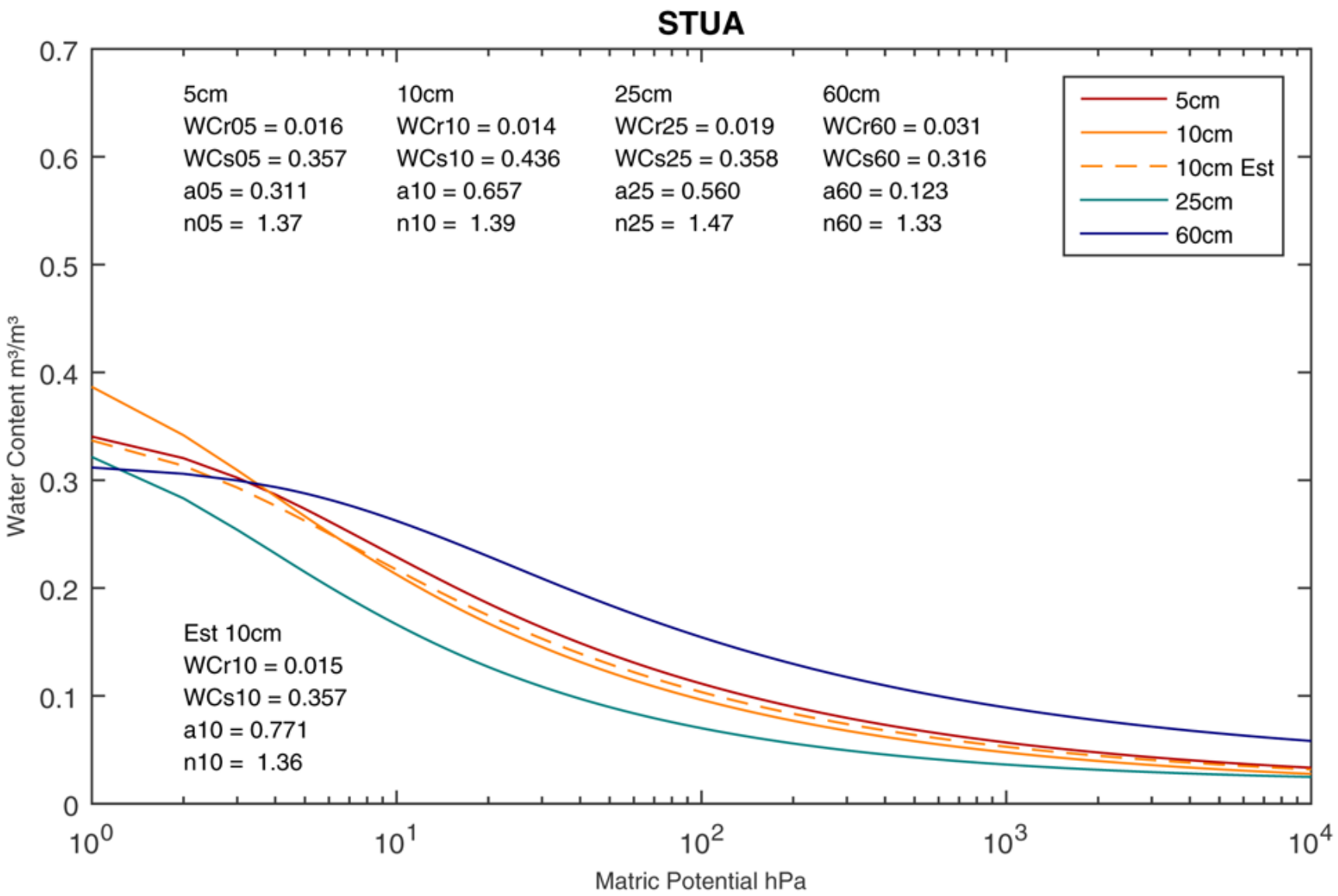
5cm: Sandy Loam
10cm: Sandy Loam
25cm: Sandy Loam



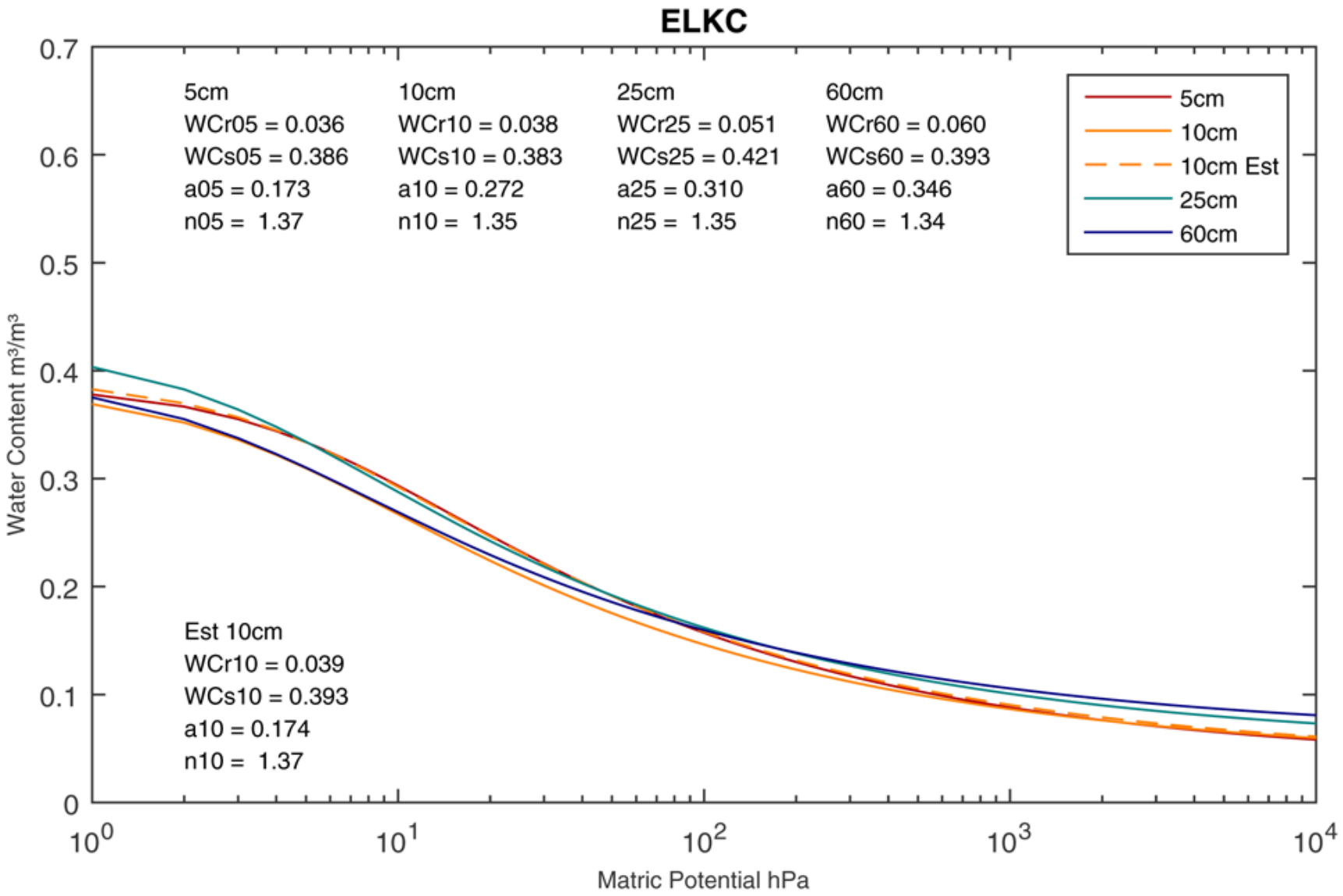
5cm: Loam
10cm: Clay Loam
25cm: Silty Clay Loam



5cm: Loam
10cm: Silt Loam
25cm: Silt Loam

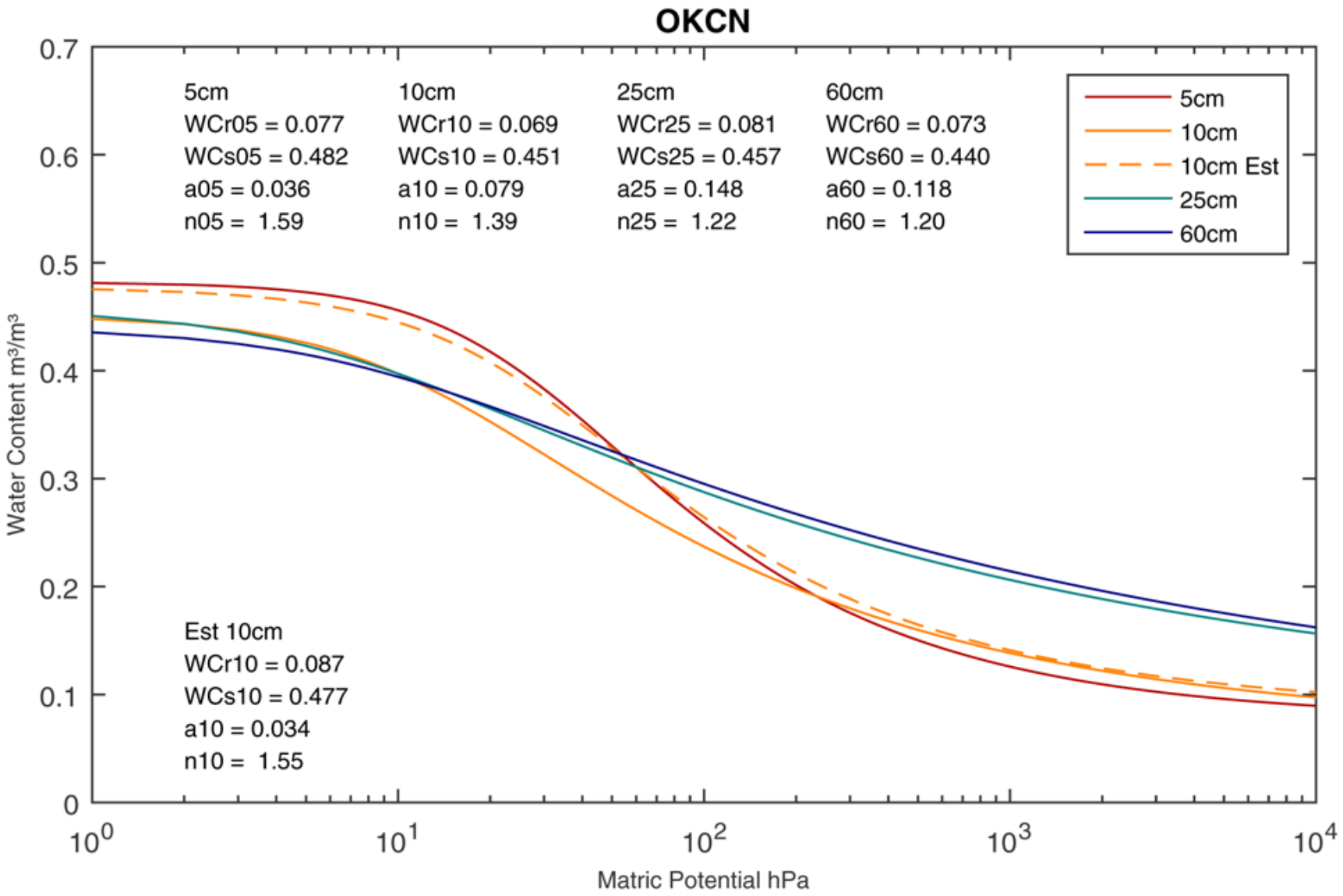


5cm: Loamy Sand
10cm: Loamy Sand
25cm: Sandy Loam

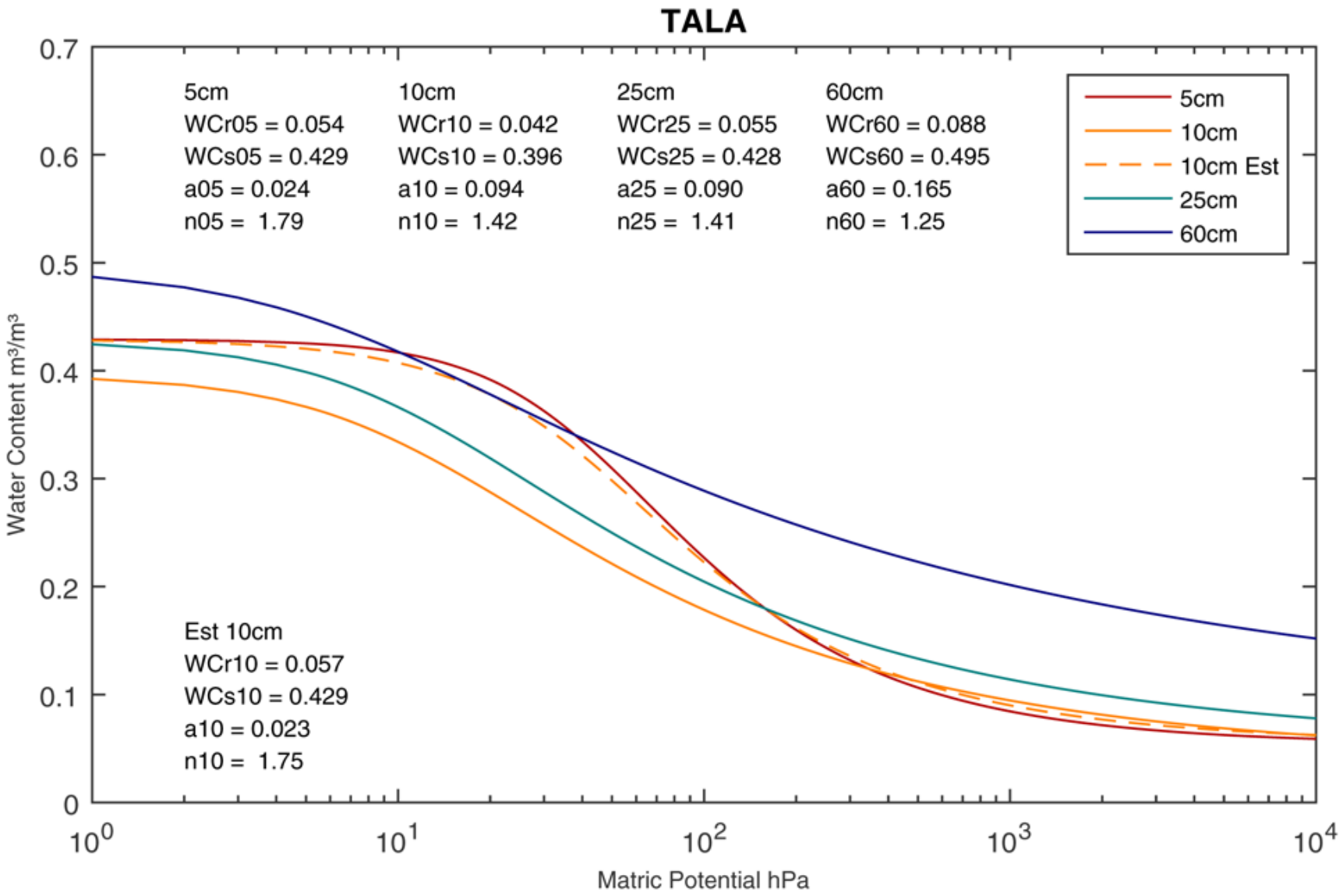


5cm: Loam
10cm: Loam
25cm: Loam

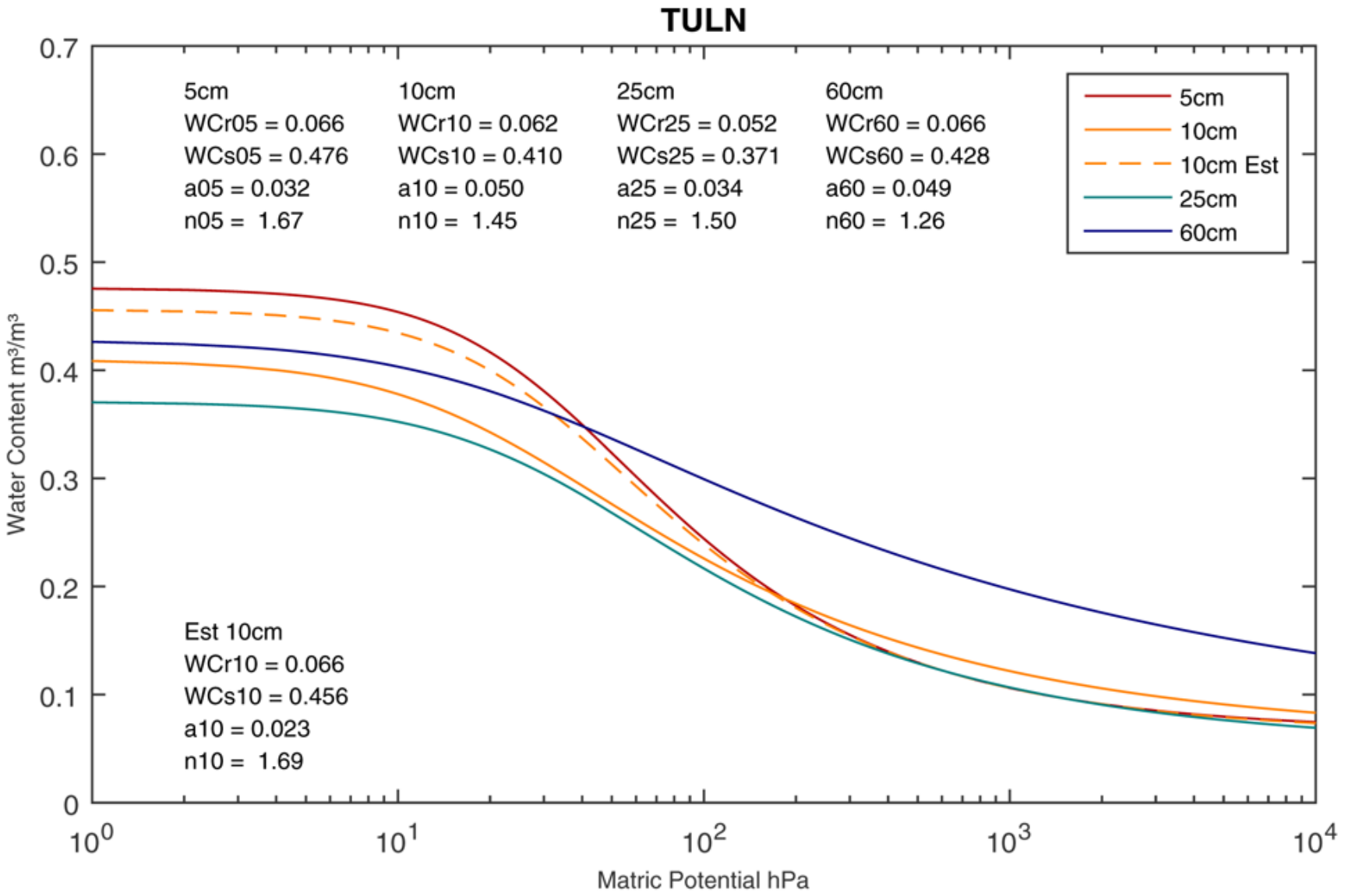
Not So Good Matches



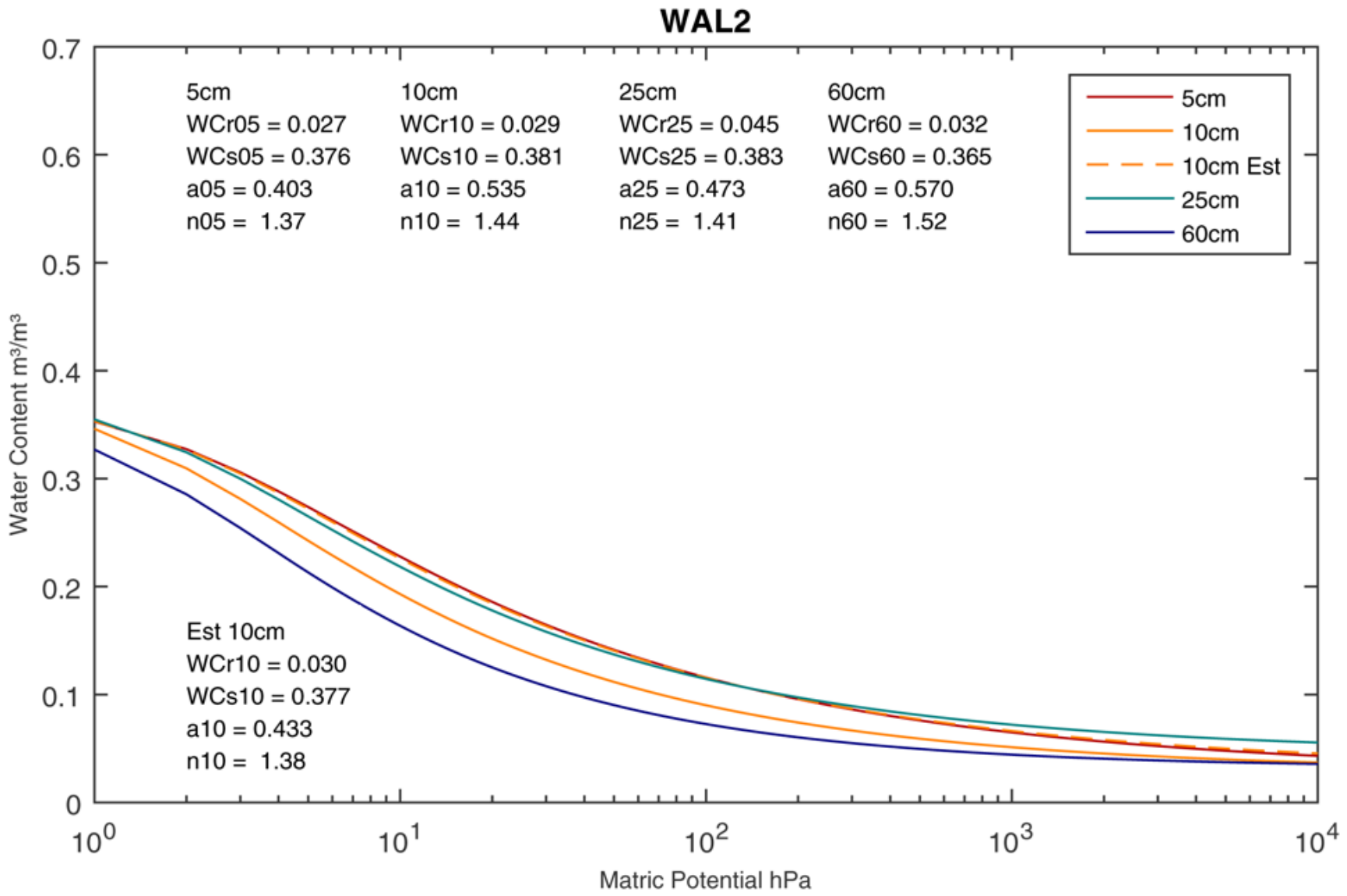
5cm: Silty Clay Loam
10cm: Silty Clay Loam
25cm: Silty Clay



5cm: Silt Loam
10cm: Silt Loam
25cm: Loam



5cm: Loam
10cm: Silty Clay Loam
25cm: Clay Loam



5cm: Sandy Loam
10cm: Sandy Loam
25cm: Sandy Loam

Open Discussion

- Different mathematical approach?
- Midpoint on soil textural triangle?
- Too many unknowns?
- How far is too far?
- What are acceptable errors?