Random sensor errors: An evaluation of differing technologies and mixed networks using triple-collocation

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Introduction: Not all measurements are created equal (Some are more equal than others)

All sensors are “wrong…” However, consistency matters a great deal.

Methodology: The one-slide lecture on triple-collocation

1. Consider three 'independent' soil moisture estimates $(\theta_1, \theta_2, \theta_3)$

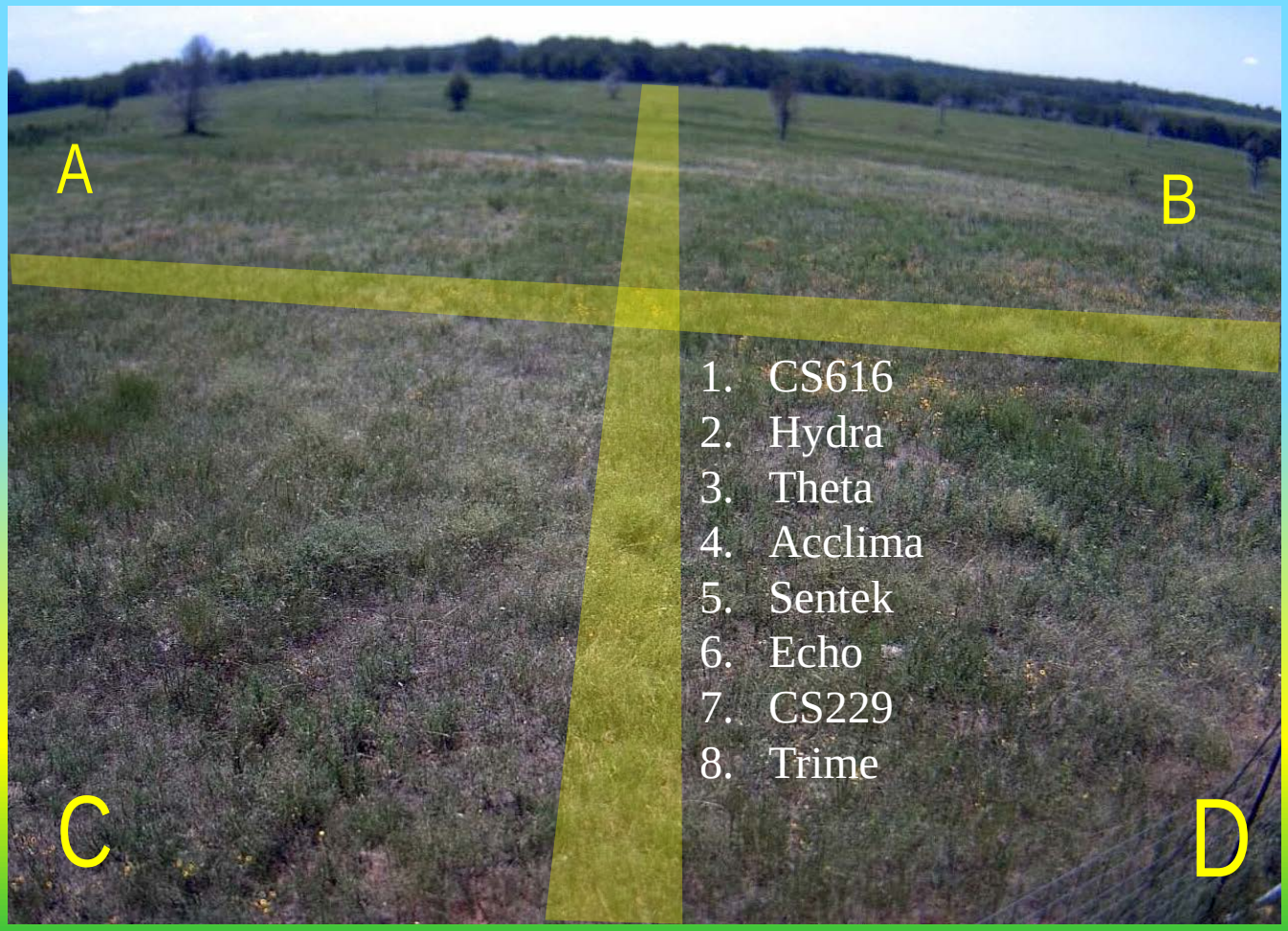
2. Subtract their means, ensuring the same numerical scale

$$\theta_{1,s}{}' = \theta_{1,s} - \overline{\theta_{1,s}} \; ; \theta_{2,s}{}' = \theta_{2,s} - \overline{\theta_{2,s}} \; ; \theta_{3,s}{}' = \theta_{3,s} - \overline{\theta_{3,s}}$$

3. Calculate random error associated with the triad of measurements $\epsilon_s = TC\left(\theta_{1,s}{}', \theta_{2,s}{}', \theta_{s,3}{}'\right)$

(A paper discussing USCRN triple-collocation estimates is currently under review in VSJ)

Four locations, three questions:
What data are available, what do we hope to learn?

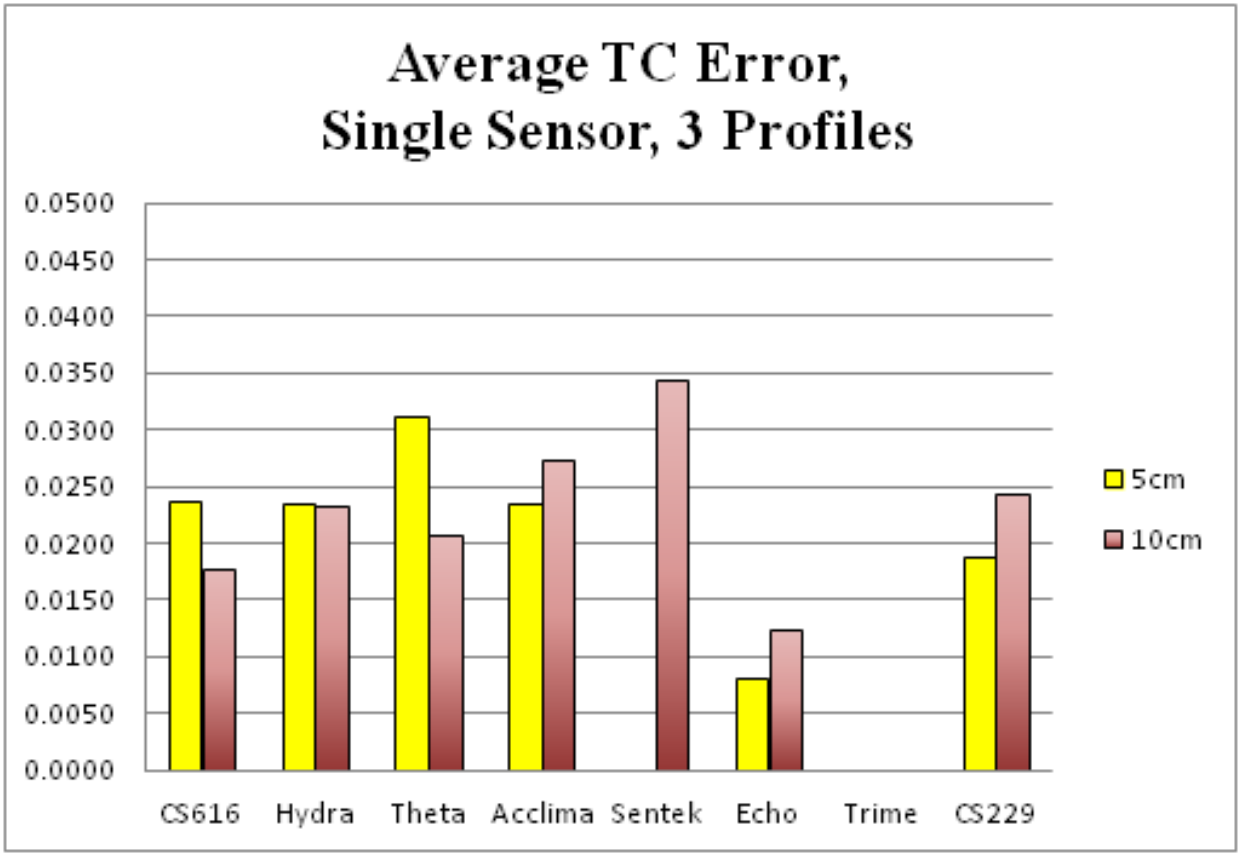


1. What is the random error associated with each technology?

2. What random errors are found from other soil moisture products?

3. What types of mixed networks perform well/poorly?

Comparing Sensors:
What is the random error associated with each technology?



1. At the 5cm depth, Theta probes produce the largest random errors (~0.030 m^3/m^3)

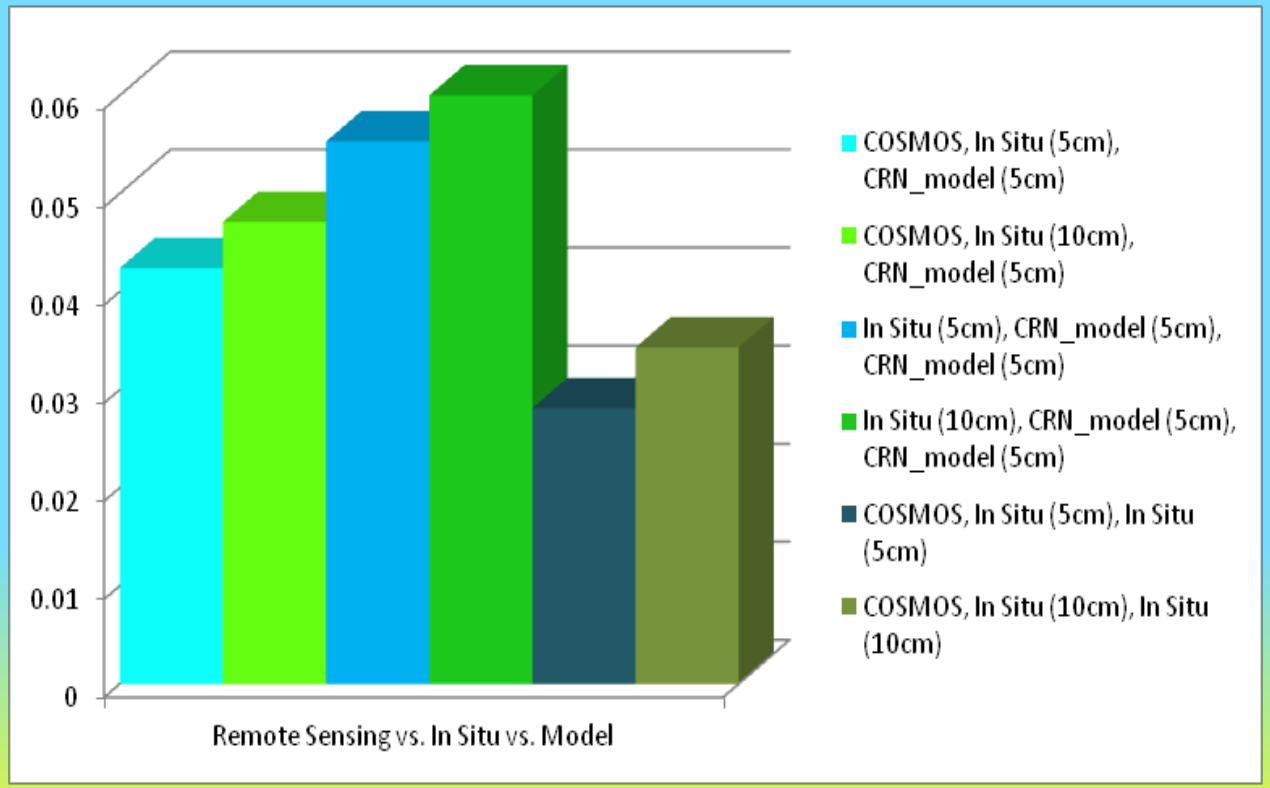
2. At the 5cm depth, Echo probes produce the smallest random errors (~0.008 m^3/m^3)

3. At the 10cm depth, Sentek probes display the largest random errors (0.034 m^3/m^3)

4. At the 10cm depth, Echo probes (again) display the smallest random errors (0.012 m^3/m^3)

(Trime sensors are only available in two locations, Sentek readings are unavailable for the 5cm depth)

Comparing Remotely-Sensed Estimates and Models: How do the errors grow as the *type* of product changes?



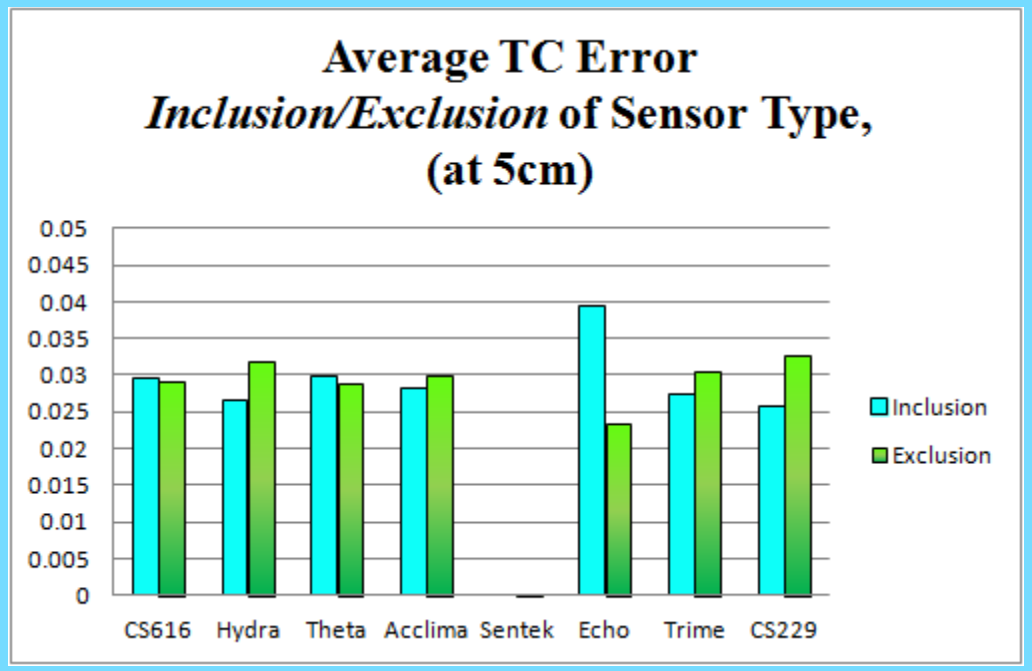
(COSMOS readings are available the MOISST test bed, CRN model estimates were calibrated using each of the paired USCRN soil moisture and precipitation gauges)

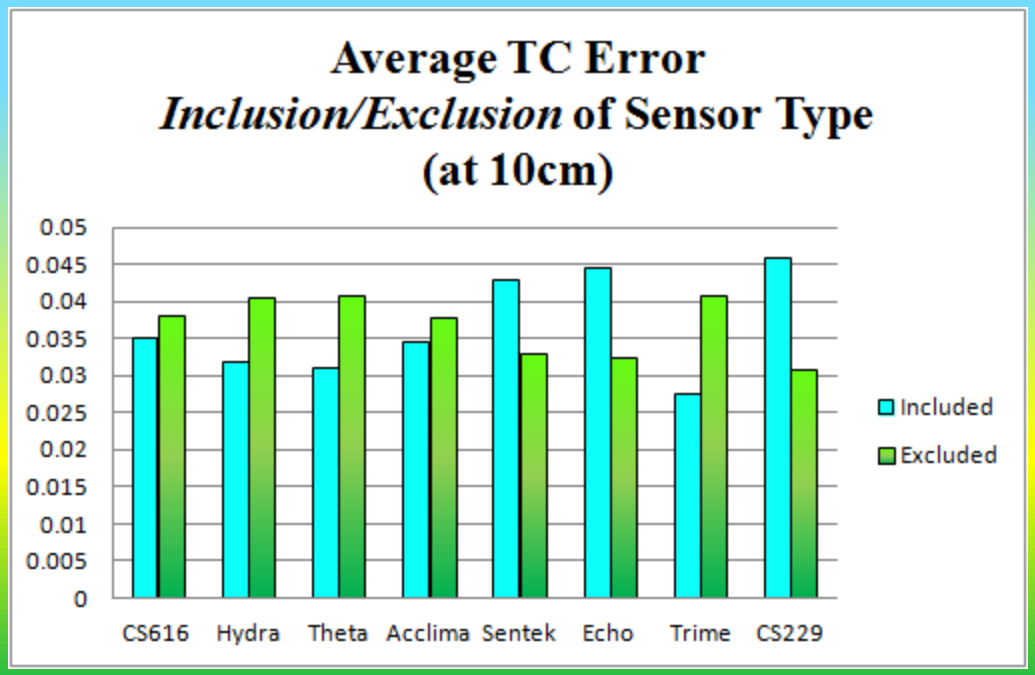
Analysis of combinations of three soil moisture products. at a single location: *in situ*, remotely-sensed (COSMOS), and model.

1. The CRN model introduces smaller errors against 5cm *in situ* sensors

2. Largest errors are obtained when model products are compared with *in situ* sensors.

3. COSMOS and *in situ* triads produce comparable errors to three *in situ* sensors. (Even though COSMOS's effective depth is larger)





Comparing Mixed Networks:

Analysis of combinations of three sensor types at a *single location* that include or exclude a specific technology.

1. At the 5cm depth, inclusion of Echo probes produces significantly larger errors. (And excluding Echo probes helps)

2. At the 10cm depth, Sentek Echo, and CS229 sensors produce much larger random errors when included.

3. Networks including Hydra, Theta, and Trime probes outperform those without

Conclusions: What do we know? (or what do we think we know?)

1. Though Echo probes are extremely consistent (small random errors), their presence increases errors in mixed networks.

2. Sentek sensors produce the largest errors in homogeneous and heterogeneous networks.

3. Integrating COSMOS sensors with *in situ* technologies presents comparable errors to all-in-situ networks.

4. Hydra, Theta, and Trime sensors offer the greatest benefit to mixed networks.