College of Arts and Sciences, Atmospheric Sciences Program

Soil Moisture Measurement Variability

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INTRODUCTION

The CS616 and HydroSense II (HS2) soil moisture sensors are two commonly used instruments to collect soil moisture data. While these sensors are used as a quick and easy way to collect data, each probe functions differently to produce a value. This raises an important question: Are some probes more accurate than others? Having accurate soil moisture measurements is vital for urban and agricultural planning, flood risk mapping, and flood planning. In this project, we compared the two soil moisture probes and analyzed how each one performs in different environments and atmospheric conditions.

Objectives:

- Is the CS616 or HS2 more accurate?
- Is the accuracy of the sensors affected by land cover?
- Does precipitation affect the accuracy of the sensors?
- Are there any correlations between environmental factors and soil moisture measurement methods accuracy?

METHODS

Six sites, three urban and three rural, were chosen for measurement around the campus of The Ohio State University. For both urban and rural environments, three locations were chosen: a forest, an open field, and a roadside location.

Map of Soil Collection Sites

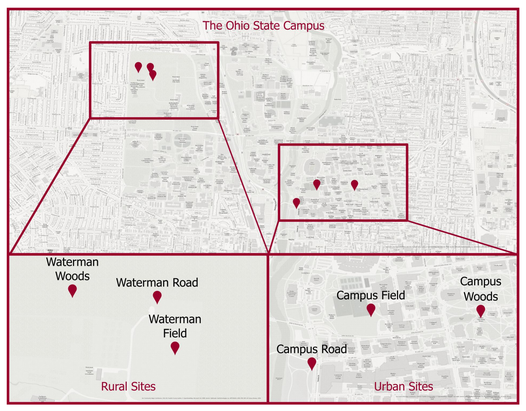

FIGURE 1. This map depicts the six soil collection sites across central Ohio.

At each of these sites, nine measurements were taken with each sensor. They were then averaged into one measurement for each location. In addition, a soil core sample was collected at each of the sites to be used for gravimetric analysis. These measurements were taken on four different days over the span of two weeks. After all the measurements were taken, the weights of the soil of the core samples before/after heating in an oven were compared to determine the volumetric water content.

Graphs of Soil Moisture Data

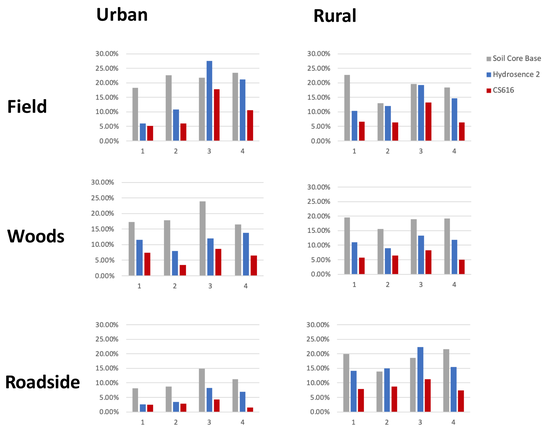

FIGURE 2. Soil moisture data collected over the course of 2 weeks at 6 different locations shows that both the sensors consistently underestimate soil moisture, especially the CS616.

RESULTS

Comparing the means of the two instruments with the measured volumetric water content of the soil core samples, it was found that the HS2 produced more accurate volumetric water content values than the CS616. Neither was as accurate as the soil core samples, as the HS2 differed by about 30%, while the CS616 differed by about 60%. Both instruments were more accurate in rural environments than urban environments, especially after precipitation events.

Spearman correlations were calculated for the urban vs rural sites and all data, between the instruments, their difference of means (DOM), soil core, and recorded weather conditions. There were more frequent and stronger correlations across the rural sites. Representative heatmaps are shown.

Statistical Analysis Matrices

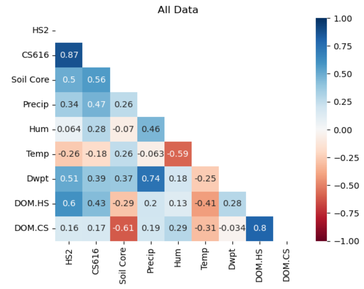

FIGURE 3. Cross-correlations of all data show moderate relationships between HS2 and dew point and between precipitation and CS616.

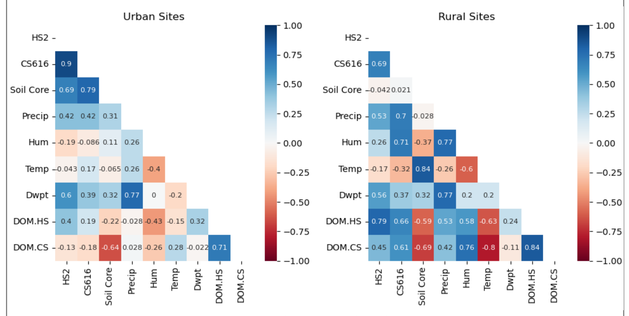

FIGURE 4. Separate cross-correlations of urban and rural data shows stronger and more consistent correlations in the rural sites. Precipitation has moderate-to-strong correlations at the rural sites.

In evaluating the impact of precipitation, both instruments performed better on Day 3, the day preceded by rain showers. The graphs below show the DOM compared to the soil core samples for both instruments in the rural and urban environments.

Urban DOM Error by Day

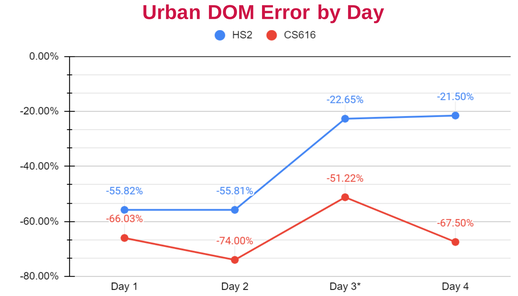

FIGURE 5. Graph of DOM for urban soil collection sites indicates highest accuracy on Day 3 (precipitation day).

It was found that the HS2 had significantly lower error values than the CS616. Both instruments also displayed lower error values at the rural sites compared to the urban sites.

Rural DOM Error by Day

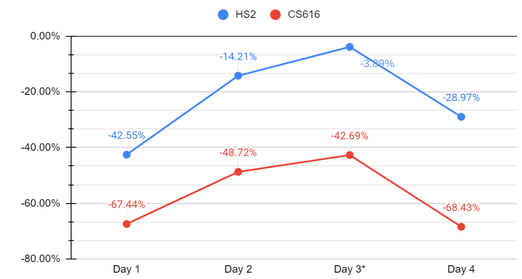

FIGURE 6. Graph of DOM for rural soil collection sites also indicates highest accuracy on Day 3.

CONCLUSIONS

- HS2 30% more accurate than CS616
- HS2/CS616 VWC measurements 30%/60% less than soil core gravimetric measurements respectively
- Rural sites had more conclusive and linear relationships between soil moisture and environmental variables
- HS2/CS616 VWC both showed strong/positive relationships with dewpoint temperature
- Precipitation improved the accuracy of both instruments in the rural environments
- Urban sites saw little to no significant relationship between the DOMs on both instruments for urban sites

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