Soil Moisture, Soil Temperature, and Land Cover in Central North Carolina

Timothy A. Henderson, Sean P. Heuser, and Joseph T. Taylor
North Carolina State University
State Climate Office of North Carolina • climate.ncsu.edu

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Introduction

While soil moisture is directly affected by precipitation, this field experiment explores how land cover contributes to soil moisture and soil temperature. Understanding how land cover affects the soil-water relationship will improve quality control for soil moisture data across NC's soil heterogeneity (Pan et al., 2012).

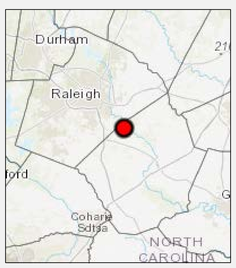
Soil Texture (Station)	Avg. Soil Moisture*	Avg. Soil Temperature*
Clay (OXFO)	0.336 m^3m^{-3}	16.84°C
Loam (NCAT)	0.324 m^3m^{-3}	17.35°C
Sand (HAML)	0.159 m^3m^{-3}	18.08°C

9-year calculated average (2008-2016) at OXFO, NCAT, and HAML ECONet stations in North Carolina, USA

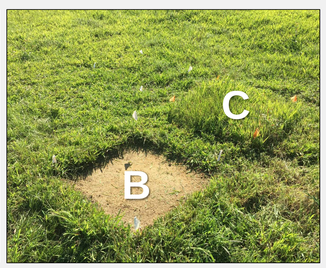
Methodology

Three, one square meter plots were marked on a research farm in central North Carolina, USA. On one plot, all vegetation was cleared, leaving only bare, loamy sand exposed at the surface, while the other plot was left to naturally redevelop.

- Soil: Varina Loamy sand, 2 to 6 percent slopes.
  - ❖ Field Capacity: 0.32 m^3m^{-3}
  - ❖ Wilting Point: 0.09 m^3m^{-3}
- Installation Date: 12:00 PM EDT on 19 May 2017 – running through present.
- Soil moisture (Delta-T ML3) and soil temperature (CS-109 and in-house-built multilevel sensor) data collected every minute through three sensors installed in each soil plot.
- Collocated with ECONet tower in Clayton, NC for air temperature, precipitation, and solar radiation data access.



Field experiment location

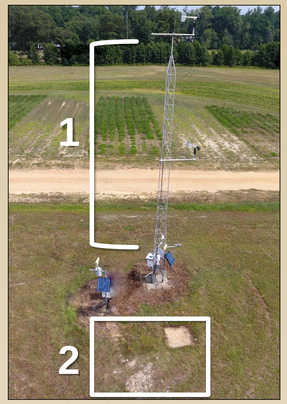


Bare soil plot (B) and covered soil plot (C)

Background and Hypotheses

Different rates of soil moisture loss are to be expected in a plot of bare soil with no rooted vegetation compared to a vegetation-rich plot with numerous, evaporation-inhibiting roots (Niu et al., 2015). With no vegetation, water is free to pass more quickly through the soil particles, yielding greater fluctuations in soil moisture within the bare soil plot.

1. Soil moisture and soil temperature in bare soil should fluctuate to greater extremes and exhibit greater variability than the plots with vegetation.
2. In the plots with covered land, less temperature and soil moisture variability should be present due to a root system and vegetation which dampen radiative heating processes and prolong water intake. Thus, average soil moisture in the covered land plot should be consistently greater than the bare soil plot.



Overview of ECONet tower (1) and field experiment (2) at tower base

Results

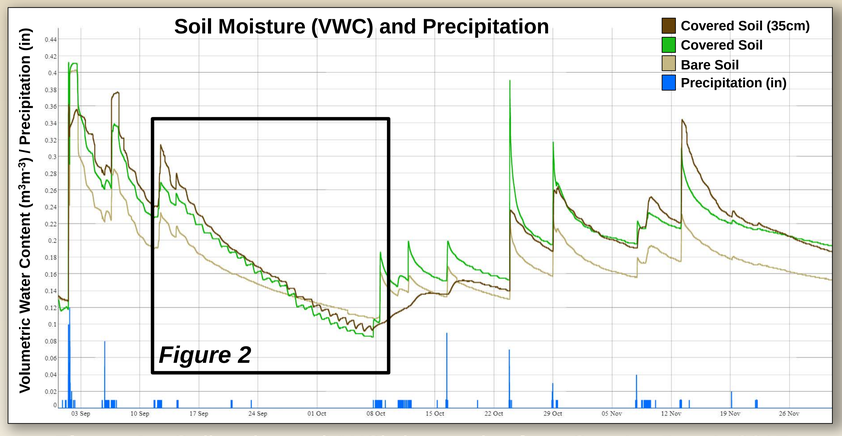


Figure 1 – *Soil moisture (VWC) time series from Sep 1 – Dec 1, 2017*

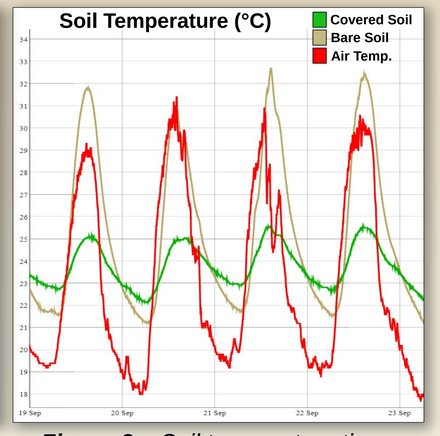


Figure 3 – *Soil temperature time series showing diurnal heating cycle*

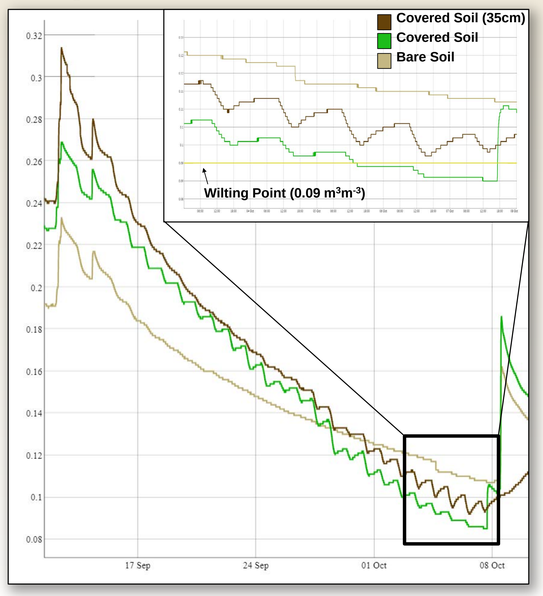


Figure 2 – *Stepladder drying effect in covered soil versus the smooth bare soil curve*

- While all sensors responded to precipitation consistently (Fig 1), the covered soil experienced a more rapid dry down due to a stepladder-like drying trend over prolonged periods of no precipitation (Fig 2).
- The bare soil moisture curve exhibited a smooth drying trend while the covered land plot lost soil moisture through a diurnal drying cycle. In August, an additional Delta-T ML3 was installed at 35cm to observe if compacted soil from decades of agricultural practices was inhibiting soil drying processes.
- Observed soil moisture data corresponded with hydraulic property measurements taken in a separate soil analysis, as soil moisture loss slowed as it approached the measured wilting point (Fig 2, inset)
- Bare soil had greater soil temperature variability than the covered soil plot due to enhanced radiative heating and cooling from the absence of vegetation (Fig 3).

Conclusions

While the range between maximum and minimum soil moisture values was equal for both soil plots (0.41 m^3m^{-3}), mean soil moisture in the covered soil was observed to be on average 0.026 m^3m^{-3}, or 12.3%, greater than the bare soil. Soil moisture values in the covered soil had a variance twice as great as the bare soil, likely due to the stepladder drying effect. Bare soil had a 0.43°C, or 1.9%, greater mean daily temperature and a 5.23°C greater overall range than the covered soil. Therefore, both hypothesis were confirmed.

Parameter	Bare Soil	Covered Soil
Mean SM	0.198 m^3m^{-3}	0.224 m^3m^{-3}
Max SM	0.506 m^3m^{-3}	0.496 m^3m^{-3}
Min SM	0.098 m^3m^{-3}	0.083 m^3m^{-3}
SM Variance	0.00349	0.00729
Mean ST	23.01°C	22.58°C
Max ST	40.96°C	38.46°C
Min ST	4.65°C	7.38°C

Statistics calculated through 1 January, 2018

Future Work

- Determining the specific effects of land cover on other soil textures and with varying types of vegetation in regard to soil moisture recharge and loss.
- Extension to observing effects of frozen precipitation and precipitation intensity.

Acknowledgments

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References

Pan, W., R.P. Boyles, J. G. White, and J.L. Heitman, 2012. Characterizing Soil Physical Properties for Soil Moisture Monitoring with the North Carolina Environment and Climate Observing Network. *J. Atmos. Tech.* **29**, 933-943.

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