Spatial prediction of near surface soil water retention functions using hydrogeophysics

Justin Gibson and Trenton Franz: School of Natural Resources, University of Nebraska-Lincoln, USA
jgibson8@huskers.unl.edu

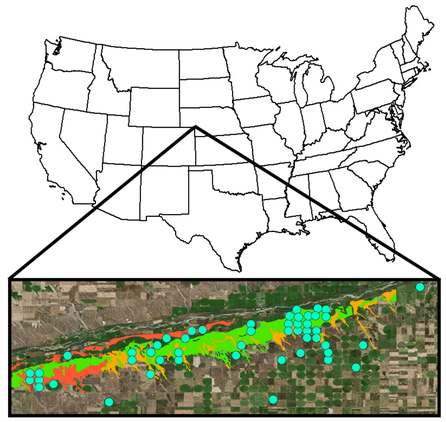
1. Introduction

- The long-term sustainability of irrigated agriculture depends on the societal agreed upon rate of aquifer decline. This rate is dependent on complex interactions in coupled social ecological systems and is defined in both terms of **water quantity** and **quality**. Additionally, the rate of groundwater pumping, water table decline, leaching, and recharge is **often poorly characterized** at both the **field** and **watershed scale**, thus limiting stakeholders' ability to make informed decisions.
- Monitoring soil moisture through the use of soil moisture sensors, and incorporating their status into irrigation scheduling can be effective in **reducing** both **pumping volumes** and the loss of applied agricultural additives (e.g. **nitrogen**). The challenge exists when selecting the number of sensors and their location to best represent the variability of a field.

2. Study Site

Site Research Objectives

1. Identify **spatial patterns** in **soil moisture** on the subfield scale.
2. Determine the **key factors** (soil properties, topography, etc.) **driving soil moisture patterns** in 3 study sites.
3. Build a locally calibrated **statistical model** to describe the relationship between soil moisture patterns and soil hydraulic properties.
4. **Predict soil hydraulic parameters** spatially where we don't have a measurement.



3. Observed Patterns in Soil Moisture

- Utilizing a **non-contact** and **non-destructive** method to measure **soil moisture** over an entire field, we are able to observe patterns of soil moisture that **persist** from **wet to dry conditions.**
- This method utilizes **repeat geophysical surveys** and a statistical analysis known as an **empirical orthogonal function (EOF)**.
- The EOF analysis indicates spatial patterns that persist from wet to dry conditions.

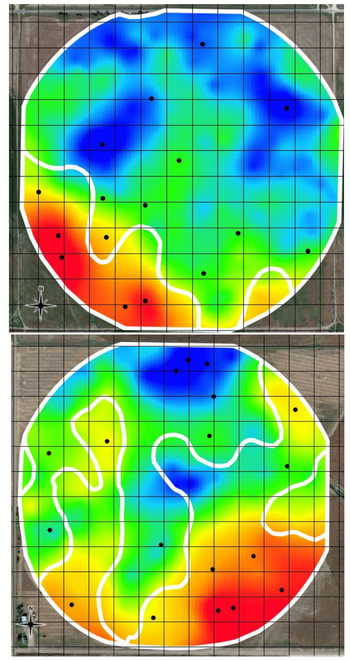


Figure 1: Comparing Empirical orthogonal functions with SSURGO zones (white lines).

4. Water Retention Functions

- Soil cores were extracted from multiple locations with the goal of capturing the range of variability determined from geophysics.
- These cores were then **analyzed in the lab** using the combination of a **HYPROP** and **WP4C** in order to have a wide range of measurement (from wet to dry).
- The water retention functions were then fit using the **van Genucthen-Mualem model.**
- Each core's water retention function was then compared with the value of each core's location in 3 different environmental covariates.

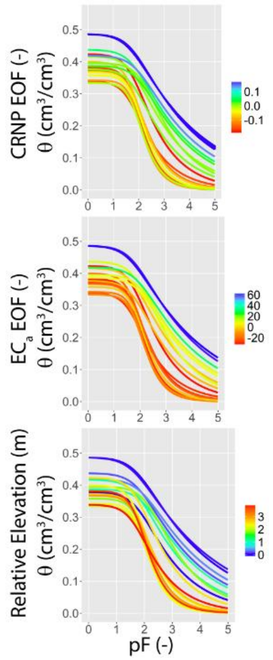


Figure 2: Water retention functions of extracted soil cores.

5. Prediction of Soil Hydraulic Parameters

- Using a linear regression between the first EOF and our soil hydraulic properties, we **predict** soil hydraulic properties **where we don't have a measurement**.
- Results were **validated** using a **bootstrap technique**.
- Using this approach **RMSE** is **reduced** by **approximately 50%** compared to SSURGO and PTF.
- RMSE values tend to converge after **5-7 training samples**.

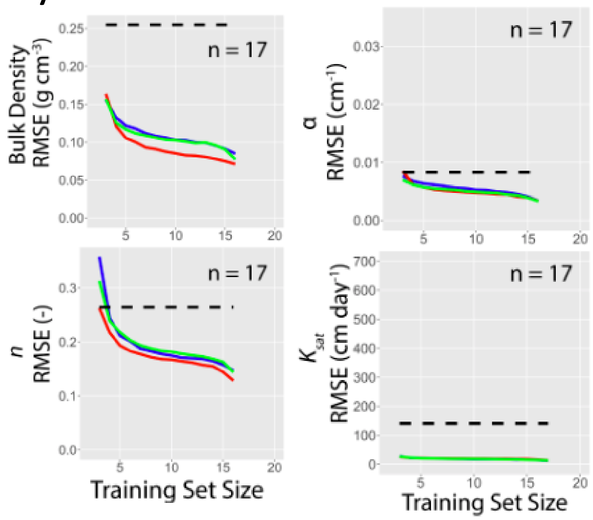


Figure 3: Bootstrap validation results where the 3 environmental covariates (CRNP EOF, ECa EOF, and relative elevation) were regressed against 1000 randomly selected training sets of sizes 3 to n-1. Dashed line is PTF estimates from SSURGO data.

Summary and Conclusions

- We observe subfield soil moisture patterns that persist from wet to dry conditions (EOF).
- Using EOF surfaces, we can strategically extract soil samples in the field.
- Using the EOF surfaces as a covariate, along with a small number of localized soil samples, we can predict soil hydraulic properties throughout a field.

Future Work

- We have extracted deep soil cores to estimate recharge and N leaching within EOF zones.

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