Using Non-Invasive Geophysical Techniques in Near-Surface Infrastructure and Food Production Management

Michaela Donahoo[1], Karim Ouamer-ali[2,3], Youcef Daoud[2], Kaddour Djili[3], Omar R. Harvey[1]

[1]Department of Geological Sciences, Texas Christian University, Fort Worth, Texas, USA. [2] *National Institute of* Agronomic *Research of Algeria* (INRAA), El-Harrach, Algeria.
[3]Ecole Nationale Supérieure Agronomique (ENSA), El-Harrach, Algeria.

Introduction

- The bulk apparent electrical conductivity (ECa) is a function of the physicochemical characteristics of a soil and can be non-invasively measured, correlated to the measured soil properties, and used to map spatial temporal variability in the soil at very fine resolution.

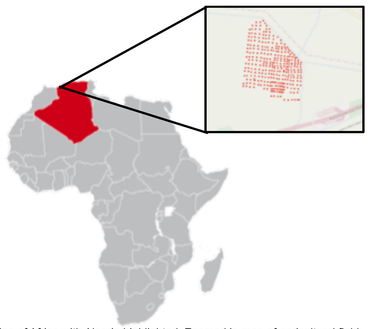
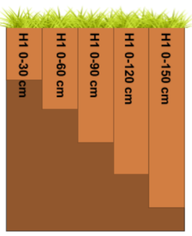


Figure 1: Map of Africa with Algeria highlighted. Zoomed in map of agricultural field. http://www.afrobarometer.org/countries/algeria-0

- Our lab group in collaboration with from colleagues in Algeria are developing models that map water content, clay content, and salinity of soils on a field scale as a function of fine depth interval using correlation to ECa. The results have name application to the agricultural and constructions sectors.

Methods

- 317 data points of ECa were collected across a farmland in the H' Madena region of Algeria using an EM38, 37 of which had complete soil information such as salinity (ECe), water content, and clay content collected 30 cm intervals (0-30 cm, 30-60 cm, 60-90 cm, 90-120 cm, 120-150 cm)



  - This was repeated across 4 surveys
    - Surveys 1 and 3 were taken at the end of the wet season and the beginning of the dry
    - Surveys 2 and 4 were taken at the beginning of the dry
- Measurements were corrected for to using Sheet and Hendricks (1995) equation
- Crop type was recorded, reporting that the field was cultivated primarily with a rotation of barley and fallow with the occasional wheat (0-120 cm root zone)
- Variables with significant correlations to ECa were determined using Spearman's analysis from the 37 point containing complete soil descriptions
- Equations based on correlation between depth specific ECa and depth average soil properties were used to develop predictions equation across at 317 data points and surveys
- We also tested for instances where one equation could be used for multiple heights or across surveys
- These results were then geospatially mapped using 3D modeling

Research Findings

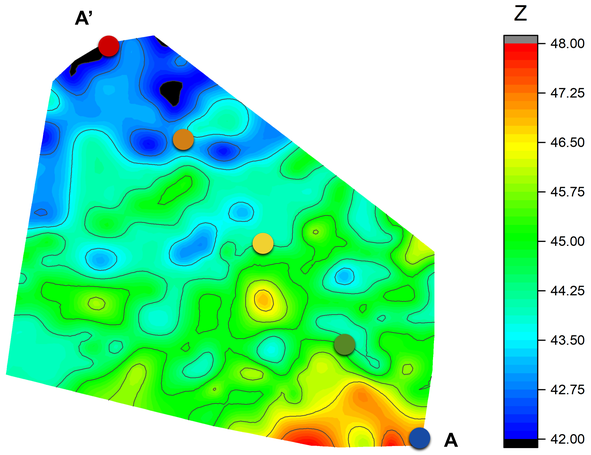


Figure 3: Elevation map of the farmland in Algeria. Black line labeled A and A' depicts where cross sections were taken.

Significance by Depth Interval and Predictive Model

- The relationship between salinity and ECa was considered significant across all surveys at all layers ($p<0.05$)
- The relationship between water content and ECa was considered significant all but the first depth interval
- All depth intervals that were determined to have a significant relationship to clay content were averaged together across surveys as clay was collected once

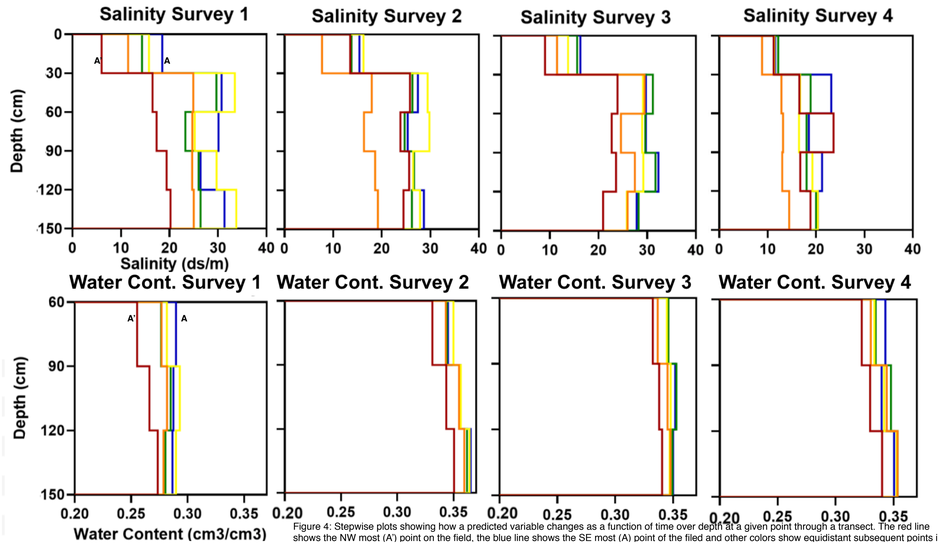


Figure 4: Stepwise plots showing how a predicted variable changes as a function of time over depth at a given point through a transect. The red line shows the NW most (A') point on the field, the blue line shows the SE most (A) point of the filed and other colors show equidistant subsequent points in

- Step graphs can be created using interval data to predict the conditions a given root zone or pipeline route would experience through a given transect
- This allows for the planning of optimal piping route by allowing managers to see how the environment will fluctuate as a factor of time and depth

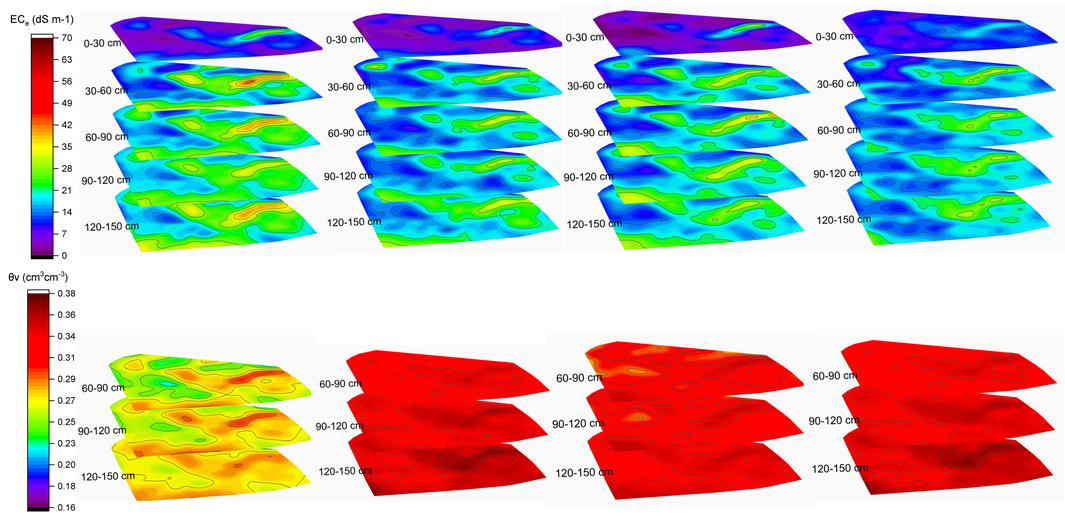


Figure 5: 3D models for each survey at the heights that were considered to have a significant relationship to ECa

- Salinity = $10^{m\log(ECa)+c}$, different coefficients needed for each height and survey
- θ_v = mlog(ECa)+c, same coefficients can be used for surveys 1 and 3 for each height but different coefficients are needed for surveys 2 and 4
- Clay % = mlog(ECa)+c, same coefficients can be used for surveys 1 and 3 for each height but different coefficients are needed for surveys 2 and 4
  - Clay values were averaged together

Conclusions

- 3D models depict the predicted values over time showing places of high and low concentration of each variable at differing depths
- Geospatial models like this with a depth aspect will be used to predict what resources a crop with a certain root zone would expect
- The combination of elevation and variable tracking allows predictions for water flow through a field
- It can also be applied for land management practices to allow the farmer to know where areas of concern or location of excess resources

Future Work

- These same processes will be applied to different soils in Texas to expand its applicability and to see how soil type influence the EC and variable relationship
- This methodology will be applied to precision agriculture, road development, and subsurface infrastructure planning (ex. pipeline, roadways, ect)

Figure 6: Map depicting different land uses in Texas. https://texasalmanac.com/topics/environment/soils-texas

References

- Harvey, O. R., and C. L. S. Morgan. 2009, Predicting Regional-Scale of Variability using a Single Calibrated Apparent Soil Electrical Conductivity Model. Soil ,Sci. Soc. Am. J.1 : 164-169.
- R. Sheets, Keith and Hendrickx, Jan . (1995). Noninvasive Soli Water Content Measurement Using Electromagnetic Induction. Water Resources Research. 31. 2401-2409.