2012 ASA-SSSA-CSSA Annual Meetings, Cincinnati, OH.

Field-Scale Soil Moisture Space-Time Geo-statistical Modeling for Complex Landscapes in the Inland Pacific NW

Maninder K. Chahal[1], David Brown[1], Erin Brooks[2], Colin Campbell[1], and Douglas Cobos[1]

UID: 73045

[1]Crop and Soil Sciences, Washington State University, Pullman, WA. [2]Biological and Agricultural Engineering, University of Idaho, Moscow, ID.

Introduction

- Monitoring and modeling soil moisture benefits precision agriculture, and is especially vital in improving dry-land cereal crop production in Pacific Northwest (Huggins and Kruger, 2008).
- The ability to measure soil moisture space-time variability has not kept pace with hydrologic model development. Hillslope-scale hydrology remains difficult to model effectively and this knowledge gap constrains our understanding of watershed soil moisture patterns.
- In the Palouse region, topographic attributes produce complex spatial soil moisture variations. Monitoring the seasonal behavior of these variations may help explain the underlying processes influencing soil moisture status.

Objective

Model the spatio-temporal variability of soil moisture at field scale in the Palouse region of the Pacific Northwest using geostatistical techniques and external covariates.

Methods and Instrumentation

- Four grower sites spanning the precipitation gradient across Palouse were selected (Fig. 1A). Using a space-filling technique, 36 locations per site were selected based upon a statistically determined inhibition distance (Fig. 1B).

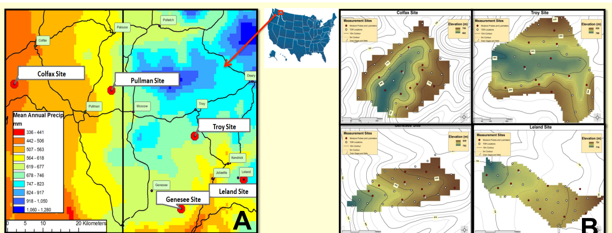

Fig. 1: A) Map of precipitation gradient across Palouse; and B) sampling locations in the study sites (Whitman County, WA and Latah County, ID).

- Soil moisture was measured at 30-cm depth using time domain reflectometry (Fig. 2) in four time events (April/May to August, 2012).
- For each time event and field, we used kriging with eternal drift (KED) to interpolate soil moisture values from measured locations, with covariates including DEM-derived elevation, slope, aspect, curvatures, and solar radiation.
- The KED models were estimated using generalized least squares regression.
- Apparent electrical conductivity (EC) data was collected with a EM38 (Geonics, Ltd) in vertical dipole. The EC maps were generated using ordinary kriging.

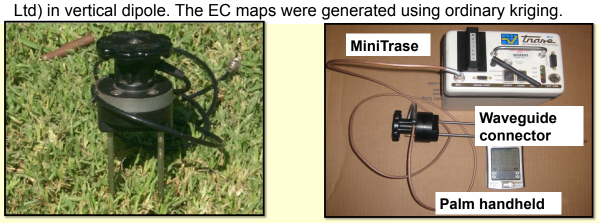

Fig. 2. Time domain reflectometry

Results

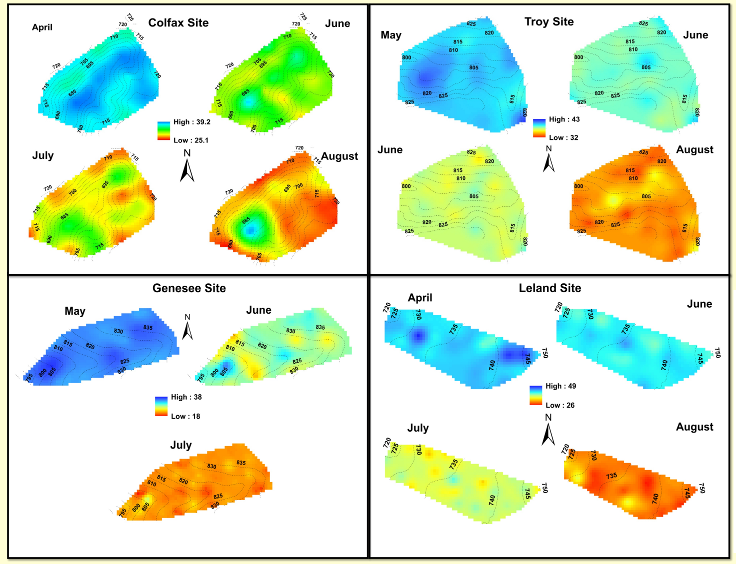

Fig 3. Spatial patterns of soil moisture over time

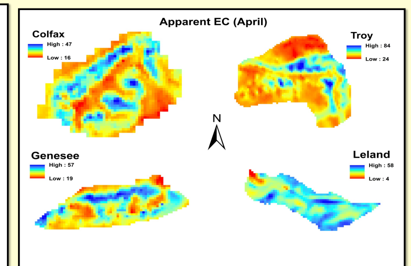

Fig 4. EC maps for all sites for the month of April

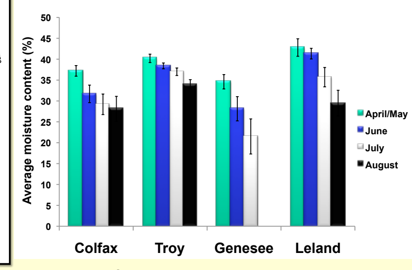

Fig 5. Variability of average soil moisture content (n=36)

Discussion and Future Work

- Soil moisture patterns at all sites are variable in space and more or less persistent in time (Fig. 3). Generally, wet areas are not drying as fast as dry areas (Fig. 3); possibly arising from flow accumulation, yet outflow is retarded by clay pans (see McDaniel et al., 2008).
- Soil moisture variability during the drying period is highest at Leland (26-49%), and is lowest in Troy (32-43%) (see Fig. 5).
- The apparent EC and soil moisture maps showed an inverse relationship, which is unreliable due to differences in sampling depths, where EC integrated a depth of 1.5 m while soil moisture measurements are based on 30 cm soil depth (Fig. 5).
- Topography played a significant role in explaining the spatial variation of soil moisture in Palouse which varies from ~7% in Troy to ~61% in Colfax. Specifically, elevation, planar curvature, and solar radiation were the most important attributes.
- The incorporation of these attributes significantly improves soil moisture prediction (root mean squared deviation decreased by ~5x) while using kriging with external drift (KED).
- However, it is shown that in circumstances where soil moisture conditions are spatially uniform, as is the case during early spring, KED is inappropriate, since there is no spatial autocorrelation. The exception to this was Genesee where slope characteristics and watershed plan appear to control the variability of soil moisture conditions.
- Future work will focus on: 1) improving the current spatial models using additional covariates (e.g. remote sensing imagery, apparent EC, and proximal soil sensing from a VisNIR penetrometer); 2) analyzing soil moisture spatial variability at higher temporal resolution; and 3) applying space-time geo-statistical methods to this problem.

References

- Huggins, D. and C. Kruger. 2008. Improving nitrogen use efficiency in dryland cereal crops with precision nitrogen management technology. Sustaining the Pacific Northwest (8). http://csanr.wsu.edu/publications/SPNW/SPNW-v6-n2.pdf
- McDaniel, P.A., M.P. Regan, E. Brooks, J. Boll, S. Barndt, A. Falen, S.K. Young. and J.E. Hammel. 2008. Linking fragipans, perched water table, and catchment-scale hydrological processes. **Catena** (73): 166-173

Acknowledgements: *Funding support from USDA-NIFA award # 2011-67003-30341*