Measuring and Estimating Soil Hydraulic Property in a Farmer's Field, Western Kentucky

Xi Zhang   Javier Reyes   Ole Wendroth
xi.zhang@uky.edu   javier.reyes@uky.edu   owendroth@uky.edu
Department of Plant and Soil Sciences, University of Kentucky, Lexington, KY 40546, USA

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Introduction

Saturated hydraulic conductivity (K_s) is an essential input parameter for hydrological models and often used as a matching point in the calculation of the $K(\theta)$ curve. K_s is a stochastic parameter and exhibits high spatial variability and scale dependency. Therefore, direct measurements are often arduous, time consuming and expensive. To avoid these problems, pedo-transfer functions (PTFs) have been developed to estimate K_s indirectly through more easily measurable soil properties that may already exist from the soil survey. However, PTFs were usually developed at large scales, including national, international and intercontinental scales. PTFs derived from large scales may not be applicable for smaller scales (e.g., field scale). The application of PTFs for estimating K_s at the field scale is still rarely reported, although most agricultural management (e.g., irrigation) occurs at the field scale.

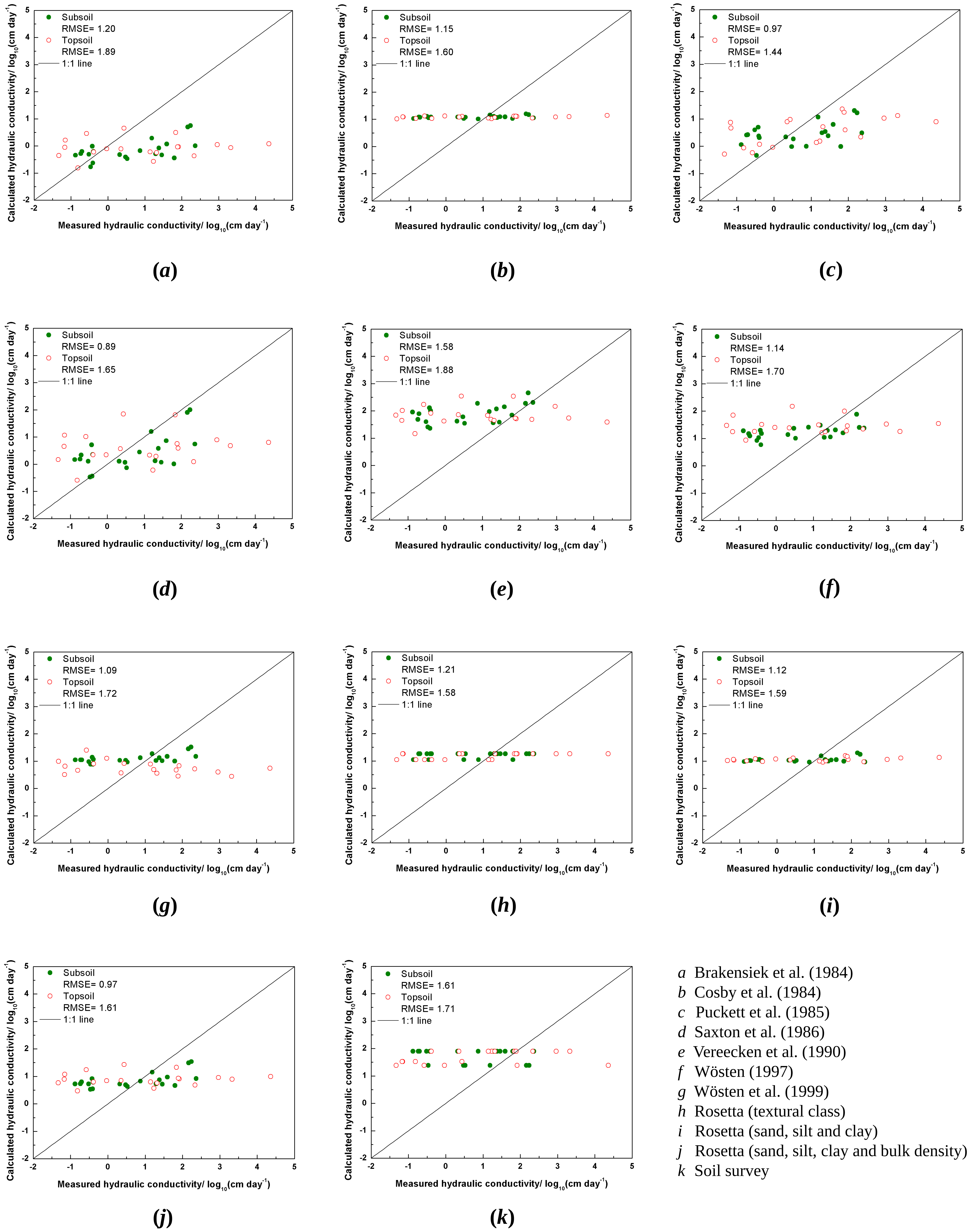
The objective of this research was to evaluate PTFs for estimating K_s at the field scale in a field in western Kentucky.

Materials and Methods

This research was conducted at the Hargis field, Hillview Farm located in Caldwell County, Princeton, KY. Wheat/ double-crop soybean/corn rotation is practiced in this farm. The field is classified as silt loam and silty clay loam soils.

Undisturbed soil cores were collected from 10 soil profiles at five depths (topsoil: 7-13 cm and 27-33 cm; subsoil: 47-53 cm, 67-73 cm, and 87-93 cm) in the field. K_s was determined with a permeameter based on Darcy's law under constant and falling head conditions. Bulk density was measured with the core method. Bulk soil is collected for texture (pipette method) and organic matter (OM) (combustion method) analysis.

Seven traditional regression models and one hierarchical artificial neural networks model were used to calculate K_s. The K_s from soil survey was also considered in this research. The performance of selected PTFs was evaluated based on root mean squared error (RMSE).



a Brakensiek et al. (1984)
b Cosby et al. (1984)
c Puckett et al. (1985)
d Saxton et al. (1986)
e Vereecken et al. (1990)
f Wösten (1997)
g Wösten et al. (1999)
h Rosetta (textural class)
i Rosetta (sand, silt and clay)
j Rosetta (sand, silt, clay and bulk density)
k Soil survey

Figure 1. Measured and estimated saturated hydraulic conductivity by pedo-transfer functions and soil survey.

Results and Discussion

All of the selected PTFs and soil survey exhibited large differences between the measured and the calculated K_s, especially for topsoil. PTFs were superior to soil survey in general.

The performance of PTFs in estimating K_s in the subsoil was comparable with the evaluations conducted by Tietje and Hennings (1996) and Wagner et al. (2001), and was better than for the topsoil.

K_s in the subsoil was found to be significantly (0.05 level) related to silt (r=0.44), clay (r=-0.46), bulk density (r=-0.59) and OM (r=0.48). However, K_s in the topsoil was only weakly related to texture, bulk density and OM.

The K_s in the topsoil probably was strongly influenced by soil structure, which development and stability are substantially affected by land management, land use history, and biological activity. Also, the presence of macropores and earthworm channels increased the uncertainties and further complicated the prediction of K_s in the topsoil by PTFs.

Conclusion

The prediction of K_s at the field scale using a PTF developed at large scale is inaccurate. The result suggests that existing PTFs need to be calibrated on local datasets or new PTFs should be developed for local field application if necessary before relevant predictions can be made.

References

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