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Hydrology and Earth System Sciences Discussions

Interactive comment on "Geostatistical modeling of spatial variability of water retention curves" *by* H. Saito et al.

M. Ye (Referee)

mye@fsu.edu

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This paper is tackling an important problem in vadose zone modeling, i.e., estimating spatially distributed water retention parameters. Such an estimation is hampered by the lack of measurements; normally the number of measurements is significantly smaller than the number of computational element (or block) of a computational grid. This paper provides two methods for resolving this problem. The Las Cruces Trench Site is unique to evaluate these two methods, since there are a large amount of measurements of the water retention parameters at the site. This makes the evaluation of the two methods interesting, I believe, to readers, although the two methods are not entirely new. Below are my comments on the paper.

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Interactive Discussion

Discussion Paper

The paper title is not very accurate. The geostatistical modeling was conducted to water retention parameters and water retention data, not the curves. Since water retention data are evaluated for estimating the water retention parameters, I think a title like “Geostatistical Modeling of Spatial Variability of Water Retention Parameters” would better reflect the paper content.

The terminologies of "parametric" approach and "non-parametric" approach may be misleading to readers with statistical background, since the two widely used terminologies have totally different meaning in statistics. Briefly speaking, the statistical meaning of the methods is that some distribution is either required (parametric) or not required (non-parametric). This study is clearly not in this context. I think the authors used the "parametric" method for the direct estimation of the water retention parameters, while the "nonparametric" approach for the indirect estimation of the water retention parameters through the water retention data. If my understanding is correct, I would suggest using "direct estimation method" and "indirect estimation method" to avoid the potential misleading.

The ordinary kriging (OK), the basis of the geostatistical modeling, requires second-order stationarity of model variables, i.e., constant (unknown) mean and covariance function as a function of distance. I am wondering if the two conditions are satisfied at the Las Cruse Trench site. The variograms shown in the paper appear fine, but how about the mean. I am not familiar with the Las Cruse Trench site, but in general, soil has layering structure, and the mean of either parameters or water content may not be a constant. If so, detrending or universal kriging will be needed. This issue may have been well studied in previous works at the site. I do not think this is a serious problem, but since this is a geostatistical paper, a rigorous geostatistical analysis would be appreciated.

The conclusion that the indirect method (nonparametric in the authors' words) gives better results than the direct method (parametric in the authors' words) appear reasonable to me. Since the water content is continuous in the domain, kriging the water

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content is justified. On the other hand, the water retention parameters are not as continuous as water content. For example, water retention parameters of different soil types may be very different. For this case, using indicator kriging for the water retention parameters would make more sense than using the ordinary kriging.

Figure 8 shows that the MAE and RMSE are about 2% and 3%, respectively, for each data on average. Although these are small values for moisture content, are they small enough relative to the average moisture content? If the average moisture content is about 20%, the error seems big to me. The same comment for Figure 9.

The authors ignore an important issue: uncertainty of the parameter estimation. There are two types of uncertainty: (1) uncertainty in the fitted water retention parameters, i.e., parameter estimation uncertainty, and (2) kriging uncertainty, i.e., kriging variance. The first type of uncertainty may not be important for the geostatistical analysis; in addition, I am not aware of methods of investigating its spatial propagation. However, the kriging variance may be important. In particular, for this paper, the indirect method (nonparametric in the authors' words) is just marginally better than the direct method (parametric in the authors' words), considering the uncertainty may somehow affect the conclusions. Our research (Deng et al., 2008, under review of Water Resources Research) shows that the kriging variance is important for parameter estimation. Considering uncertainty may be beyond the scope of this paper.

I would also like to suggest another way of estimating the water retention parameters using cokriging. The method was originally used by Yates and Warrick (1987), and recently by Ye et al. (2007). The idea would be to use moisture content data as secondary variable to estimate the water retention parameters, the primary variables. Since the number of measurements of water retention data and retention parameters are the same, one may say that it does not make sense to use the cokriging method. However, the Las Cruse Trench Site is unique in that the cross-validation and jackknife methods can be used to investigate whether the water content data can be used to improve the parameter estimation. If this is true, we can measure more water content

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data for characterizing heterogeneity, since measuring water content is much easier and less expensive than measuring water retention parameters.

Some minor comments If the authors prefer using the parametric and nonparametric methods, I suggest defining them clearly in the abstract so that readers with statistical background would not be misled.

Figure 2 uses the coordinates of x and z, Figures 4, 7, 11 – 13 use x and y. Since it is a trench, the coordinates of x and z make more sense to me.

Yates, S. R. and A. W. Warrick (1987), Estimating soil water content using cokriging, Soil Sci. Soc. Am. J., 51, 23-30.

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