$$\sigma_k^2 = \sum_{i=1}^{n} \lambda_i \gamma(x_i x_0) + \mu \qquad [4]$$

where $\mu$ is a Lagrange multiplier that enters through the minimization.

In order to make their calculations the authors have used the fact that both the estimation variance Eq. [3] and the kriging variance Eq. [4] depend only on the choice of the hypothetical variogram and the number of nearest neighbors used in the calculation.

Philip and Watson (1986) have strongly criticized use of the kriging variance as a measure of accuracy of interpolated values. They point out that the kriging variance cannot be a measure of local variation because it is determined solely by the kriging geometry and the variogram, which is global in nature. Philip and Watson (1986) argue that.

> With the construction of the experimental semi-variogram, differences in local values of the function being estimated are averaged through the data set. If, in one location we have large amplitude, short-wavelength variation then lag differences are averaged with other locations where the converse can obtain. And the result is that variation is everywhere averaged and nowhere known.

In response to their criticism Journel (1986) has acknowledged

> Neither estimation variance, nor its minimised version the kriging variance are data-values dependent. They depend solely on data configuration and variogram model and are thus area specific indexes of data configuration, *not* measures of local accuracy. Only an arbitrary Gaussian construct could allow deriving confidence intervals from these variances.

Warrick and Myers (1987) calculated their "error variances" corresponding to Eq. [4] above [in Warrick and Myers (1987) the unnumbered equation following their Eq. [7]] for five common variogram models. In the light of the preceding extracts it is apparent that the relative error variances produced by Warrick and Myers (1987) are in fact values of a data configuration index. This data configuration index can tell us nothing about the local variation or the number of samples required to achieve a given level of accuracy. As a result, the planning of sampling strategy based on the estimation variance or the kriging variance of geostatistics will be of little use to field scientists trying to cope with the difficulties of soil heterogeneity. Moreover, although not stated by Warrick and Myers, their standardized tables require *a priori* knowledge of the integral length scale and variance of the process under study before they can be used.


## Acknowledgment

Thanks are due to my colleague Dr. Ian White for valuable discussion.

Received 11 Dec. 1987



*CSIRO Division of Environmental Mechanics* M.J. SULLY
*GPO Box 821*
*Canberra, ACT 2601*
*Australia*


## References


Journel, A.G. 1986. Geostatistics: Models and tools for earth sciences. Math. Geol. 18:119–139.

Philip, G.M., and D.F. Watson. 1986. Matheronian geostatistics—quo vadis? Math. Geol. 18:93–117.

Warrick, A.W., and D.E. Myers. 1987. Sample error variances with standardized variograms. Soil Sci. Soc. Am. J. 51:265–268.


## Reply to "Comments on Calculations of Error Variances with Standardized Variograms"

Dr. Sully is correct in noting that the kriging variance is not data dependent; this has been well known for more than a decade. The estimation variance, i.e. the variance of the error of estimation of *Z(x)*, is the objective function used to determine the weights in the kriging estimator. It is appropriate to choose a sample location pattern that minimizes the optimized value of the estimation variance. We did not translate this into a confidence interval.

Obviously the results given in our note require prior knowledge of the variogram. We believe this was clearly stated. Although not a specific objective, the effects resulting from an incorrect variogram is a pertinent question and one that has been considered by several authors.

Received 28 Dec. 1987


*Dep. of Soil and Water Science* A.W. WARRICK
*429 Shantz Bldg., no. 38* D.E. MYERS
*The Univ. of Arizona*
*Tucson, AZ 85721*