The Local and Global Confidence Uncertainty Plumes of SAKWeb©

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ABSTRACT

SAKWeb© (Spatial Autocorrelation and Kriging Web) is the first Internet geosoftware that provides access to a wider audience to boost spatial analysis knowledge in conjunction with new tools (Negreiros, 2004). Under this geoweb solution, it is possible to create a local and a global uncertainty plumes after any Ordinary Kriging interpolation. To highlight and to compare both approaches using the same spatial contamination dataset becomes, thus, the core of this poster. It is expected that these accomplishments might be used by Geographic Information Systems (GIS) users with risk assessment troubles to layout a first raw global and local confidence plume.

1. PREAMBLE

Spatial data lives with risk analysis. Uncertainty is a dimensionless parameter for which high values are bad and lower ones are optimal. Thus, uncertainty must be space geometry dependent because areas away from sample locations hold higher uncertainty. As well, it must take into account the variability of sample values. Using a hypothetical dataset with 100 observations (mean=56, variance=1500, skewness=4, minimum=24.9, maximum=317), to highlight and compare two different spatial uncertainty approaches that take into account both factors after Ordinary Kriging (OK) interpolation (as illustrated by figure 1) assessment becomes, thus, the main topic presented here.

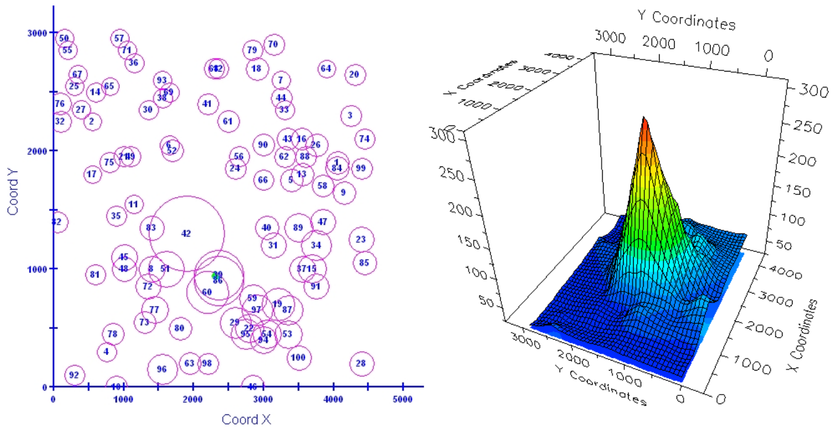

Figure 1: Samples plotting layout (left) and OK estimation (right) based on an isotropic spherical variogram (nugget-effect=0, range=1200, sill=1800).

2. LOBAL UNCERTAINTY PLUME

Ordinary Kriging (OK) is a geostatistical estimation technique. It uses a linear combination of surrounding sampled values to make such predictions. Based on Kriging interpolations, one possibility to create a raw Gaussian confidence interval, a hard spatial assumption, could be the use of the error Kriging variance (σ^2_{OK}) for a particular confidence level index (CLI): KrigingPrediction $\pm CLI \times \sigma^2_{OK}$, where CLI factor follows the values of the Normal distribution with zero mean and variance of one. This means that for each Kriging prediction and for a certain confidence level, the OK variance should be added and subtracted to each interpolated value by a CLI factor. As expected, the CLI parameter equals 1.645, for instance, if the confidence level is 90%.

Due to preferential sampling, SAKWeb© declustering is based on the nearest neighbourhood analysis where each sample weight relies on the nearest neighbour distance among all samples and the estimated one (see Negreiros, 2004, for further discussion). It is than possible to generate a 90% (Kriging_Prediction $\pm$ 1.645×σ_{OK}) or 80% (Kriging_ Prediction $\pm$ 1.282×σ_{OK}) global confidence interval, for instance, with a major result improvement due to a neighbourhood declustering. On the basis of the Normal error distribution, SAKWeb© simulates the minimum and maximum global plume for three confidence intervals (80%, 90% and 95%). The mapping of the largest and smallest area above a specific threshold can, then, be achieved (as illustrated by figure 2). As expected, to setup the cutoff value is a user responsibility.

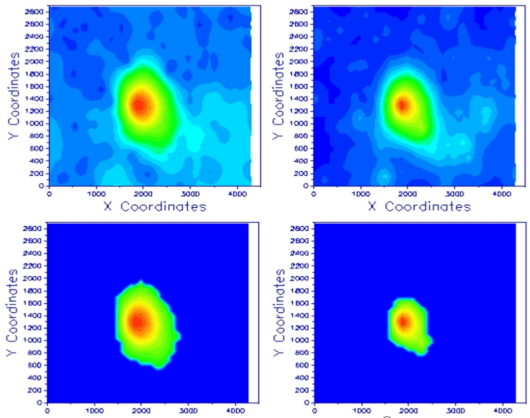

Figure 2: The Global Region Confidence Interval of SAKWeb©: (1) The two above images show the highest and the lowest plume for a 80% confidence level of the OK estimation of figure 1; (2) The under left map illustrates the region above (worst scenario, if a cleaning operation is considered) the threshold value (130 ppm) while the right figure shows the below (best scenario) one.

3. LOCAL UNCERTAINTY PLUME

An extension of SAKWeb© to enhance the local confidence interval is based on the local error variance as a true representative of the local pattern of spatial continuity. Since the shape of the variogram is the same for the whole study region, a hard spatial assumption, to rescale the local variogram should be computed to reflect local spatial variability. According to Isaaks and Srivastava (1989), the error variance of a relative variogram with a sill of one multiplied by the conventional local variance achieves this aim in a proper way. In practical terms, to produce a variogram sill of one, each coefficient of the original model should be divided by its sill (upper left map of figure 3).

With regard to the conventional local variance assessment, moving neighbourhood statistics can help this estimation. Under SAKWeb©, this local variability is computed based on the local error variance whose local range equals the greatest value of the lag with the highest Moran I found (upper center map of figure 3). Once the local error variance has been assessed based on the samples values that are within the range of the estimation point, then each local standard deviation uncertainty is multiplied by the rescaled OK error variance (upper right map of figure 3). Parallel to the previous global uncertainty measurement, SAKWeb© offers the Normal 80%, 90% or 95% confidence intervals for the OK prediction but reflecting local conditions.

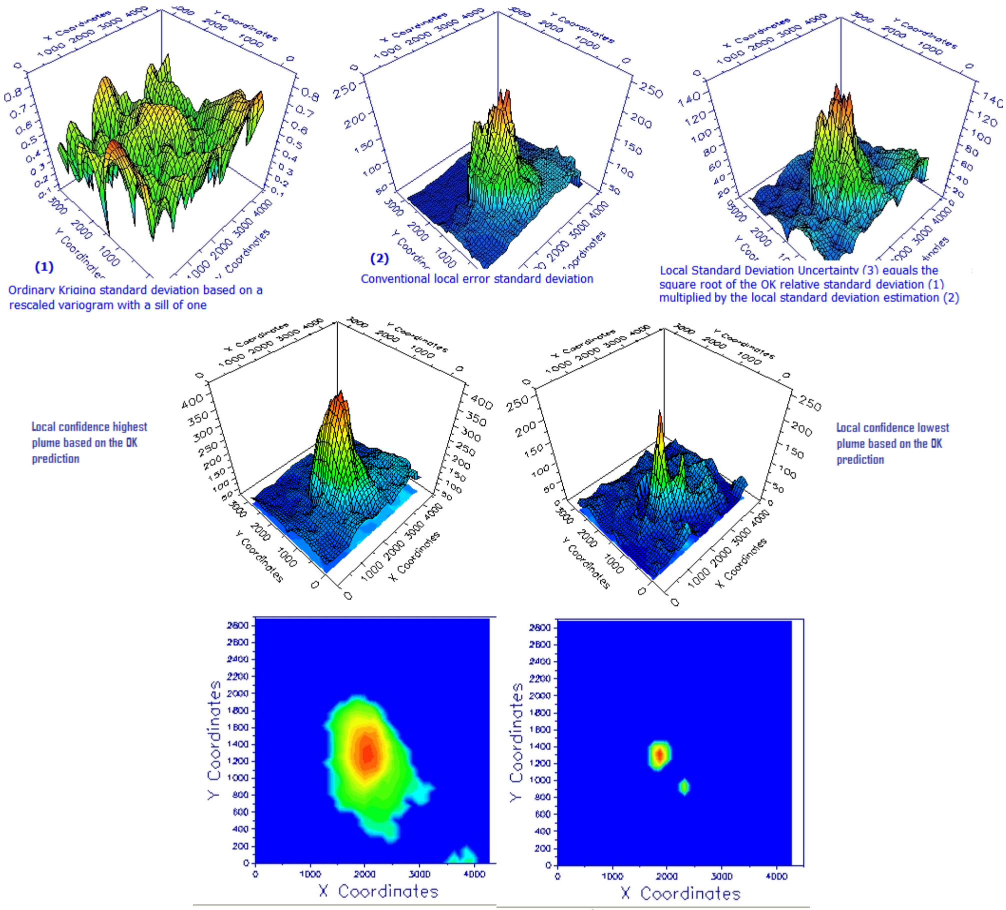

Figure 3: The Local Region Confidence Interval of SAKWeb©. Analogous to the previous situation, both bottom maps illustrates the highest and lowest plume for the same cutoff value of 130 ppm.

4. FINAL THOUGHTS

SAKWeb© follows the belief of bringing spatial analysis tools for the W3 environment since Internet is an ingredient of our future (Negreiros, 2004). Two SAKWeb© measures of uncertainty are briefly compared here. As expected, different results were shown. How can these risk measures be useful? With agricultural applications, administrators might be interested to know how much of the whole population would give a higher return than the value of a certain crop while, within environmental issues, supervisors might be looking at toxicity levels. The same question arises when the fishery service computes water salinity and the density of shellfish (Goovaerts, 1997). Irrespective of the circumstances, the question is to determine how much of the population is likely to lie above or below a cutoff limit. To define those risk assessment areas is the aim of these plumes based on a probabilistic thinking. In conjunction with a cost analysis technique (not available in SAKWeb©, yet), it would be, then, possible to assess a first comprehensible cleanness cost for this particular region.

BIBLIOGRAPHY

Goovaerts, P., Geostatistics for Natural Resources Evaluation. Oxford University Press, 1997.

Isaaks, E., Srivastava, R., An Introduction to Applied Geostatistics. Oxford University Press, New York, 1989.

Negreiros, J., SAKWeb (Spatial Autocorrelation and Kriging Web) – A W3 Computation Perspective. Unpublished Ph.D. Thesis, 449p, 2004.