Master Physical Geography, Spatial Analysis and GIS 2 (geo4-4412) 2008
Final test
Date: Thu Nov 6, 2008, 13:00–16:00
Please show intermediate results, in addition to your answers
(16 points in total)

Question 1

a. (1 point) Describe the typical variogram parameters; nugget, sill and correlation length.

b. (1 point) What is the difference between conditional simulation and prediction? When would you use it?

c. (2 points) There are two figures on the last page of this test. Figure 1 shows four different variograms (sample variograms and variogram models). Figure 2 shows four different random field, simulated with one of the variograms in figure 1. Tell which variogram belongs to which random field. Explain your answers.

Question 2 Given the following data set (x and y refer to spatial coordinates):

x	y	measurement
0	0	0
0	1	0.5
0	2	1.0
0	3	1.5

a. (1 point) Calculate the semivariance for lag (h) equal to 1, 2 and 3, given:

$$\gamma(h) = \frac{1}{2N_h} \sum_{i=1}^{N_h} (Z(s_i) - Z(s_i + h))^2$$

b. (1 point) Why do we need to fit a variogram model to the sample variogram before using it in kriging or simulation?

c. (1 point) If the measurement at location (0,3) was 4832 instead of 48, would you recommend using kriging? Explain why.

d. (1 point) If we use kriging to predict a value at location (0,2), what would the kriging prediction and kriging variance be?

e. (1 point) Calculate the covariance matrix between the observations (V) and the covariance vector between the prediction and the observations (v). The covariance function is equal to $C(h) = e^{-h}$.

f. (2 points) Calculate the simple kriging predictor and prediction variance for location (0,4), given the data set. You will need these formulas:

$$\hat{Z}(s_0) = \mu + v'V^{-1}(Z - \mu)$$
$$\sigma^2(s_0) = \sigma_0^2 - v'V^{-1}v$$

You do not need to invert V, use V^{-1} as given below. Instead of the v calculated in e, use the v that is given. Assume that μ equals the mean of the data. Use the same covariance function as in question e.

$$V^{-1} = \begin{bmatrix} 1.16 & -0.43 & 0.00 & 0.00 \\ -0.43 & 1.31 & -0.43 & 0.00 \\ 0.00 & -0.43 & 1.31 & -0.43 \\ 0.00 & 0.00 & -0.43 & 1.16 \end{bmatrix}, \quad v = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0.5 \end{bmatrix}$$

Question 3

a. (2 points) Give a short description of each of the following methods.

* Cokriging
* Inverse distance weighted interpolation
* Splines
* Ordinary kriging
* Universal kriging

b. (1 point) Describe for which situations you would use universal kriging and which cases you would use cokriging.

c. (2 points) Below you can see a summary of the results of a leave-one-out cross-validation. Give a short description of cross-validation and the outcome. What can you say about the cross-validation below? Would you recommend the model that was used in this case? Explain your answer.

```
Object of class SpatialPointsDataFrame
Coordinates:
     min    max
x 178605 181390
y 329714 333611
Is projected: NA
proj4string : [NA]
Number of points: 155
Data attributes:
   var1.pred       var1.var         observed       residual
 Min.   :3.31   Min.   :0.0815   Min.   :4.73   Min.   :-2.4128
 1st Qu.:5.15   1st Qu.:0.1504   1st Qu.:5.29   1st Qu.:-0.8614
 Median :5.94   Median :0.1686   Median :5.79   Median :-0.0923
 Mean   :5.91   Mean   :0.1758   Mean   :5.89   Mean   :-0.0194
 3rd Qu.:6.67   3rd Qu.:0.1930   3rd Qu.:6.51   3rd Qu.: 0.7066
 Max.   :8.69   Max.   :0.5656   Max.   :7.52   Max.   : 2.0853
     zscore             fold
 Min.   :-6.8541   Min.   :  1.0
 1st Qu.:-1.9210   1st Qu.: 39.5
 Median :-0.2155   Median : 78.0
 Mean   :-0.0299   Mean   : 78.0
 3rd Qu.: 1.5079   3rd Qu.:116.5
 Max.   : 7.1019   Max.   :155.0
```

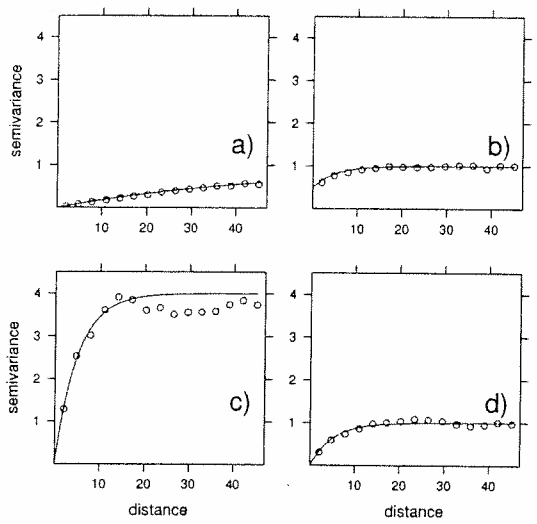

Figure 1: Variograms from simulations

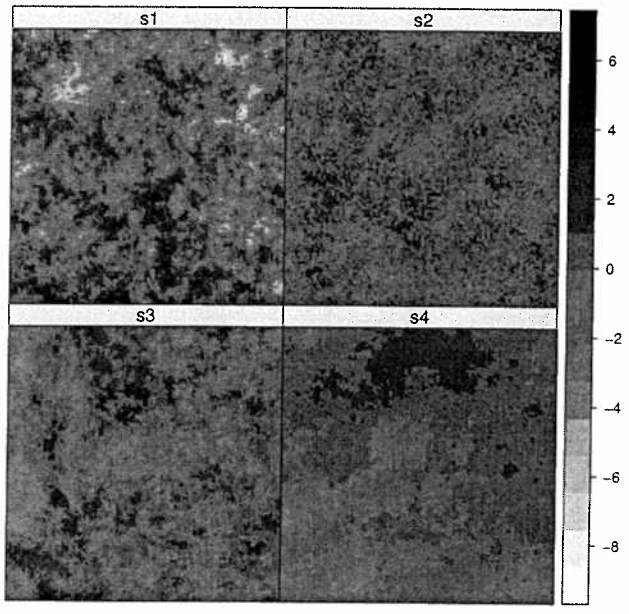

Figure 2: Simulated fields from the variograms in Figure 1