Homework #4
Data Analysis and Geostatistics, Fall 2020

Quantifying spatial variability - experimental variogram

Download the dataset of accumulation rate estimates from Devon Ice Cap from the course Google Drive, `Geostats/DevonBdot.txt`.

The first column is distance along a transect near the ice cap summit in meters, and the second column is the accumulation rate in water equivalent in centimeters. Load this dataset into MATLAB.

1. Subdivide the data into 4 different continuous sections (each $\sim$ 200 meters long) , calculate summary statistics and plot the relative density histogram and kernel pdf of the accumulation rates in each section.

2. Are the first two basic assumptions of second order stationarity approximately correct (i.e. constant mean, constant variance)?

3. Calculate the semivariance, covariance, and autocorrelation and plot.

4. Using Monte-Carlo simulation, plot the uncertainty in semivariance for random samples of the point pairs for a constant number of pairs of points, N_p, at each lag. Show the uncertainty for N_p =10, 50, and 100 pairs of points.

5. Plot the semivariance for the 4 different equal continuous sections that you used above. Is the third assumption of second order stationarity approximately correct (i.e. semivariance depends only on the lag)?

Modeling the variogram

6. Using the experimental variogram for the entire dataset, fit a bounded linear model:

$$\begin{aligned} \gamma(h) &= \frac{c\,h}{a} \qquad & h \le a \\ &= c \qquad & h > a \end{aligned} \tag{1}$$

   where c is the sill and a is the range. Do this using a brute-force method, by looping over a range of values of c and a.

7. Repeat using the MATLAB function `fminsearch.m` to find the best parameters.

8. Using `fminsearch.m`, fit a spherical model to the experimental variogram:

$$\begin{aligned} \gamma(h) &= c\left(\frac{3h}{2a} - \frac{h^3}{2a^3}\right) \qquad & h \le a \\ &= c \qquad & h > a \end{aligned} \tag{2}$$

9. Add a nugget to the model and repeat.

10. Plot all 4 variogram models along with the experimental variogram.

Uncertainty in the variogram model

11. Choose your best variogram model from the 4 above. Using 100 Monte-carlo simulations, fit the model using 50 point pairs at each lag, using `fminsearch.m`.

12. Plot the experimental variogram with the median modeled variogram at each lag and 95% uncertainty limits on the modeled variogram, from your 100 variogram models.

13. Plot the relative density histogram and kernel pdf for each of the variogram model parameters (sill, range, and nugget).

14. Repeat for 150 point pairs at each lag