Exercise 4 - Simple and ordinary kriging

Office hours: Friday 09:00-12:00

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The objectives of this 4th exercise are (1) to investigate geometric anisotropy, (2) to perform simple and ordinary kriging and (3) to compare the performance of different interpolation methods.

For this exercise, we will use the "precipitation 2011" dataset (available on moodle). The dataset consists of 432 measurements of total annual precipitation for 2011 (in mm) collected by MeteoSwiss rain gauges at different locations over Switzerland. For validation purposes, the dataset is divided in two separate files: "precipitation_2011_prediction.txt" contains 332 measurements that will be used for structural analysis and interpolation. The file "precipitation_2011_validation.txt" contains 100 additional and independent measurements that will be used to evaluate the accuracy of the different interpolation methods.

A R code (ex4.R) showing how to read and analyze the data is already provided. Information about the syntax and arguments of R functions is available via the *help* within R. A short but useful tutorial is also available on moodle.

1. Read the prediction dataset and compute the isotropic sample variogram of the precipitation values. Hint: do not specify any values for the width, the cutoff or the boundaries (gstat will choose them for you). Fit a spherical variogram model. What are the values of the nugget, the sill and the range of the fitted model?

2. Compute the variogram map (2D variogram) of the precipitation values. Hint: use a width of 10 km and a cutoff of 90 km. What are the directions of minimum and maximum variability?

3. Compute the variograms in the direction of minimum/maximum variability. Hint: use the option "alpha" in variogram() and an angular tolerance of tol.hor=15°. Do not specify any values for the width, the cutoff or the boundaries (gstat will choose them for you). Hint: In gstat, angles are measured in degrees clockwise from the North.

4. Fit a spherical model on each of the directional sample variograms computed above and provide the values of the nugget, the sill and the range of the fitted models. What is the value of the anisotropy ratio, i.e., the ratio between the range in the direction of maximum variability and the range in the direction of minimum variability?

5. Use the results obtained in 2. and 3. to define a new variogram model with geometric anisotropy. Hint: have a look at the option "anis" in vgm(). Make sure to define the range along the major direction, i.e., the direction of minimum variability.

6. Interpolate the precipitation values at the locations of the validation dataset.

(a) using inverse distance weighting (IDW).
(b) using simple kriging and the isotropic variogram model computed in 1.
(c) using ordinary kriging and the isotropic variogram model computed in 1.
(d) using ordinary kriging and the anisotropic variogram model computed in 5.

Hint: The code for IDW is already provided. For the other interpolation methods, see the help of krige().

7. Compare the interpolated values with the precipitation measurements of the validation dataset. Compute the bias and the root mean squared error (rmse) of the predicted values for each method. Which method performs best? And which performs worst?

8. Read the provided 1-km digital elevation model (DEM) for Switzerland and interpolate the precipitation values at the locations given by the DEM.

   (a) using inverse distance weighting (IDW).
   (b) using ordinary kriging and the isotropic variogram model.
   (c) using ordinary kriging and the anisotropic variogram model.

   Hint: The main part of the code is already provided.

9. Plot the maps with the interpolated precipitation values over Switzerland. What are the main differences between the different interpolation methods?