Exercise 5 - Universal kriging

Office hours: Friday 09:00-12:00

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The objective of this 5th exercise is to perform ordinary and universal kriging and to compare the performance of these methods for data that exhibit a clear trend over the considered domain.

For this exercise, we will use the "data-Ex5.zip" dataset (available on moodle). The dataset consists of 109 measurements of average annual temperature for 2011 (in degrees Celsius) collected by MeteoSwiss weather stations at different locations over Switzerland, as well as the 1-km DEM of Switzerland. For validation purposes, the dataset is divided in two separate files: "temperature_2011_prediction.txt" contains 80 measurements that will be used for structural analysis and interpolation. The file "temperature_2011_validation.txt" contains 29 additional and independent measurements that will be used to evaluate the accuracy of the different interpolation methods.

A R code (ex5.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 plot the empirical probability density function (pdf) of the temperature values. Is normality a good assumption?

2. Plot the average annual temperature with respect to the altitude. Is there a trend?

3. Use the function "lm()" to fit a linear regression model for the temperature vs the altitude. What are the coefficients (intercept and slope) of the fitted model and the residual standard error? Hint: use the function "summary()" to get useful information about the fitted linear model.

4. Compute the isotropic sample variogram of the temperature values using Cressie's robust estimator and the boundaries provided in the code. Fit a spherical model on it. Show the sample variogram and the fitted model on the same graph. What are the values of the fitted nugget, sill and range?

5. Compute the isotropic sample variogram of the temperature values (with the same boundaries as before) using Cressie's robust estimator and a linear trend with respect to the altitude. Fit a spherical variogram model on it and provide the fitted values of the nugget, the sill and the range. What can you say about the new values of the nugget and the sill?

6. Interpolate the temperature values at the locations defined in the validation dataset.
   (a) using ordinary kriging (OK) and the variogram defined in 4.
   (b) using the linear model (LM) defined in 3.
   (c) using universal kriging (UK) and the variogram defined in 5.

Compare the interpolated values with the temperature 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? Explain why!

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

   (a) using ordinary kriging (OK)

   (b) using universal kriging (UK)

   Plot the maps with the interpolated temperature values over Switzerland. What are the main differences between the considered interpolation methods?