GEOSTATISTICS

Prof. Eric PIRARD

Work load: 30h Theory (lectures), 30h Practice (lab) 32h Project work.
Number of credits: 5 ECTS
Course code: GEOL0097-2
Source: http://www.emerald.ulg.ac.be/?q=geostatistics

► *Course contents:*

1. Computers and Geosciences

2. Computer Assisted Conception / Perception
2.1. Quantitative Geology / 2.2. Encoding of geological data

3. Analysis of a unique geo-variable (univariate statistics)
3.1. General principles of sampling / 3.2. Visualisation of univariate data/ 3.3. Characterization of a sample data set / 3.4. Statistics for directional data / 3.5. Modelling and statistical inference / 3.6. Tests for comparisons between populations / 3.7. Analysis of variance

4. Analysis of simultaneous geo-variables (bivariate statistics)
4.1. Remark on homo and heterogeneous data spaces / 4.2. Bivariate data visualisation / 4.3. Characterization of a sample data set / 4.4. Interpolations and regressions

5. Introduction to spatial data analysis
5.1. Spatial sampling strategies / 5.2. Levelling of data sets from multiple campaigns / 5.3. Introduction to mapping and spatial interpolation.

6. General principles of spatial modeling
6.1. Probabilistic vs. Deterministic Modelling / 6.2. Standard techniques of deterministing modelling

7. Introduction to regionalized variables
7.1. Random variable and random function / 7.2. Random function and regionalized variable / 7.3. Characterization of the spatial law / 7.4. The covariance function / 7.5. The theoretical variogram / 7.6. Ergodic and stationarity hypotheses

8. Modelling the variogram
8.1. The theoretical and the experimental variogram / 8.2. Variogram models / 8.3. Omnidirectional variogram modelling / 8.4. Modelling the anisotropy / 8.5. Cross-Variogram and co-regionalisation

9. Local grade estimation
9.1. Conditions for optimization of a non-biased linear estimator / 9.2. Simple Kriging / 9.3. Ordinary Kriging / 9.4. Kriging in presence of a spatial drift / 9.5. Influence of the geometry of the

neighbourhood and variogram shape on the estimation / 9.6. Cross-validation / 9.7. Kriging and secondary information / 9.8. Stratified Kriging / 9.9. Co-kriging

10. Local uncertainty and local distribution estimation
10.1. Kriging and estimation error / 10.2. MultiGaussian approach / 10.3. Indicator kriging / 10.4. Spatial uncertainty and geostatistical simulations

► *Intended Learning Outcomes:*

• Be familiar with the basic notions of uni- and bivariate statistics. Understand the importance of a quantitative approach in geosciences.
• Be able to make use of graphical display, exploratory data analysis and statistical analysis tools used in geology.
• Be able to analyze the distribution laws generated by different geological processes and to compare them to the theoretical laws available for modelling.
• Be acquainted with the use of software tools for data processing
• Understand advantages and drawbacks of the main geostatistical inference tools
• Be capable of reading and understanding the most advanced papers on spatial inference
• Be familiar with the most common professional geostatistical applications

► *Prerequisites and co-requisites:*

None

► *Planned learning activities and teaching methods:*

Interactive lectures using PPT allow student interaction between students and professor. Every (2h) lecture is complemented by a (2h) practical session letting the students work on real datasets.

All practical sessions are organized using open software for statistical studies i.e. Python and SGeMS. Sampling datasets of different origin (ore anomalies, environmental data, …) are provided to the students to deal with basic statistical problems during the initial practical sessions. An individual dataset of a sampling campaign for metallic ore exploration is provided to each of the students for development of their own personal project. The aim of this project is to integrate all theoretical background in a realistic 3D case by performing a complete geostatistical analysis, estimate the grade and tonnage of the sampled area, and identify possible mineable areas.

Invited speakers provide real case experience and aid during some of the practical sessions.

► *Mode of delivery (face-to-face; distance-learning):*

- Theoretical courses are given by modules of 2 hours.

- Practice work (2h) on computer is supervised by assistant and researchers.
- Face-to-face discussions with young researchers in the field. Supportive learning during practical lessons by working on datasets both in group and individually.

► *Recommended or required readings:*

<u>Required:</u>

Power Point presentations available through the student portal (MyULg)

GOOVAERTS P., 1997, Geostatistics for natural resources estimation, Oxford Univ. Press

<u>Recommended:</u>
Isaaks E. & Srivastava M., 1989, Introduction to applied geostatistics, Oxford Univ. Press
Cressie N., 1993, Statistics for Spatial Data, Wiley.

► *Assessment methods and criteria:*

Oral examination bears on theoretical principles. Final notation is a weighted average : 75% (oral examination) + 25% (personal work). None of these two notes being inferior to 7/20. If the oral examination is 10/20 only this last note is taken into account.

► *Contribution to EIT's Overarching Learning Outcomes:*

(EIT OLO5 and OLO6): This course overviews descriptive statistics and introduces spatial geostatistics. The students have to deal with 3D datasets for ore mineral anomalies detection (real examples for exploration targeting). They are invited to use different inference methods and assess the limitations and uncertainties of their results.