Project Summary: Integrated analysis of geoscientific data

Geoscience is generally based on information acquired under difficult conditions, often resulting in insufficient, inaccurate, and often inconsistent data. For this reason, geoscientists have been amongst the leaders in the development of advanced data analysis methods. Geophysical inversion - a method for computing models of the Earth, based on noise contaminated data and geological constraints - is one such method. It has been developed to an advanced level, where the information on data and geological structures is fully probabilistic, and where the combination of these sources of information is based on rigoristic rules (Tarantola, 2005).

In recent years, an interesting further development has taken place. The first experiments with the use of complex geological information as probabilistic constraints in inverse problems have been carried out (Barnes, 1997; Strebelle, 2002; Zang et al, 2006; Lange et al. 2012). The methods are built on learning strategies where pattern frequencies in geological images are used to represent geological structures statistically. The methods look promising, but today it is still unclear how to avoid unwanted bias in the models generated by such methods.

The aim of this collaboration project is to develop the necessary mathematical theory to be able to describe the full information content of geological structures and lithological sequences as displayed in geological images. Furthermore, we will develop algorithms that allow calculation of unbiased (minimum information/maximum entropy) probabilistic models of such images. Fulfillment of these goals will allow us to develop algorithms for geophysical data inversion where probabilistic geological constraints are incorporated. The intermediate step consisting in defining lithological random fields and multipoints statistics on it is the hardest difficulty to overcome.

Working program

The problem definition and the basic mathematics statements for the derivation of a joint probability distribution from given marginals is planned for the first week. Different algorithms are to be tested but the key idea is to find a minimum information/maximum entropy probability distribution consistent with given marginals (unbiased). Tests on simple cases with integration of geophysical and geological information based on spatial lithological multiple-point pattern statistics are to be achieved. Part of the tests as well as the preparation of an article on that subject is planned for the 2nd week. A seminar given by Klaus Mosegaard on the probabilistic description of structural and lithological information and on these methods is also planned during the stay.

Bibliography

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