Post-doctoral position at BRGM

Imprecision in kriging-based spatial interpolation for environmental applications

Post-doc duration: 12 months with possible extension – expected starting date: September 2025 (flexible)

Location: BRGM, 3 avenue Claude Guillemin, BP 36009, 45060 Orléans (with some short duration stays at IRIT, Toulouse - Romain Guillaume, Hélène Fargier, and UTC Compiegne - Sébastien Destercke).

Main supervisor: Jeremy ROHMER

Context

Kriging constitutes the key ingredient to the geostatistical methods created by Georges Matheron in the 1960s (Matheron and Blondel, 1962) with multiple applications to deal with spatial interpolation problems in Geosciences (Chilès and Desassis, 2018). One advantage of kriging is to provide the variance of the predictions, which is useful in practice to quantify the confidence in the spatial predictions and guide sampling procedures. However, a common criticism is that its predictions do not take into account the uncertainty in the estimation of the model parameters. Consequently, the variance of the predictions is often too optimistic, hence resulting in neglected uncertainties, which can have a significant impact. This problem is made worse for smaller data sets.

As a remedy, a Bayesian approach was proposed by several authors (Handcock and Stein, 1993; Kitanidis, 1996; Krivoruchko and Gribov, 2019) with diverse comparison exercises (Helbert et al., 2009; Al-Mudhafar, 2019; Wieskotten et al., 2024).

An alternative, potentially complementary, approach has been proposed in the literature. The key is to rely on the combination of different tools to represent the state of knowledge and to model the different sources of uncertainties (data, parameter estimates, modelling choices, etc.). Depending on the origin of uncertainty (aleatory, epistemic, both), these tools can be based on probabilities but also on intervals, fuzzy sets, possibility distributions, imprecise probabilities, etc. (Destercke et al., 2008). This is the starting point of different developments (Bardossy et al., 1990; Diamond, 1989; Loquin & Dubois, 2012; Mangili 2016; Bean et al., 2022).

Research framework

This proposed postdoctoral position is part of the ANR HOUSES research project funded by the French Research Agency (https://anrhouses.github.io/). Within this project, the candidate will interact with colleagues with diverse expertise: uncertainty theories (IRIT, UTC-HEUDIASYC), geostatistical methods (ARMINES) and environmental applications (BRGM, HESUS).

Work plan

In this view, the post-doctoral candidate will perform two tasks:

Task 1. Extension of the imprecise Kriging approach

Previous developments have mainly focused on simple or ordinary kriging. This is the case of Loquin & Dubois (2012) which can handle imprecision in the measurements (in the form of intervals or fuzzy intervals) and variogram with ill-known parameters (e.g. imprecise length scales). The first objective is to extend these developments to universal kriging to include in the predictions the effect of covariates. A possible option is to combine these developments with those of Mangili (2016). A second line of development aims to extend the approach to structural uncertainties, i.e. related to the choice of models used, for instance the uncertainty in the choice of the variogram model (Gaussian, Exponential, Matérn etc.).

Task 2: Comparison / benchmark from an operational viewpoint

Based on the developments, the second objective is more operational and aims at identifying the benefits, limitations or complementarities of the imprecise kriging compared to existing methods for different real case situations.

The envisioned real cases are:

- The mapping of trace element (Selenium, Sulfate, Arsenic) concentrations in groundwater in the Paris basin (see e.g. for the context, Gourcy et al., 2011), where the question of measurements' censoring is key and can be tackled using different tools, either probabilistic or interval-based;
- The construction of geological models of the sub-surface, where the question of structural uncertainties and human interpretation is key (Courrioux et al., 2015);
- The mapping of sand sediment thickness on the dune systems in the Pays de la Loire (see context by Billy et al., 2020), where the effect of clustering is essential;

Competencies

- PhD thesis in probability/statistics/data science, if possible in spatial statistics
- Competencies in programming (R or Python)
- Taste for real-case applications.

Contact

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