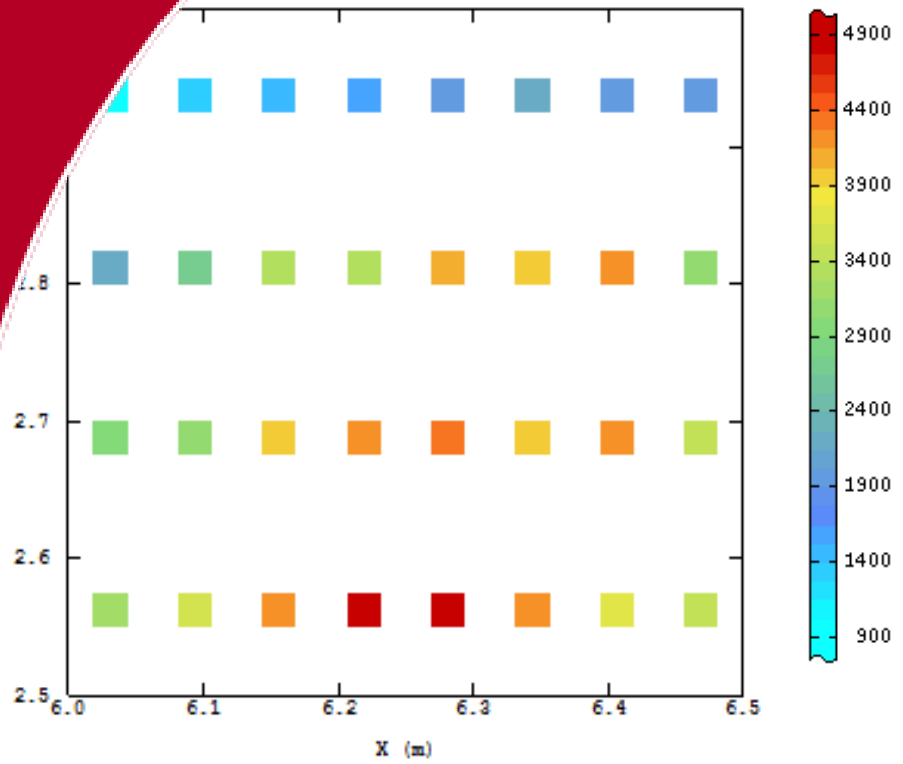
Studsvik

Geostatistical characterisation of contaminated metals: methodology and illustrations



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Symp. on Recycling of Metals arising from Operation and Decommissioning of Nuclear Facilities, April 8 - 10, 2014

Agenda

Geostatistical characterisation of contaminated metals: methodology and illustrations

- Introduction
- Active culvert decommissioning
  - Objective
  - Experimental
- Geostatistics
  - Active culvert data
  - Syntethic example
- Conclusion

Introduction

- Radiological characterisation plays an important role in the process to recycle potentially contaminated metals
  - Platform for planning, identification of the extent and nature of contamination, assessment of potential risk impacts, cost estimation, radiation protection, and management of material (decommissioning, release, and disposal of generated secondary waste)
- The entire sampling strategy should be optimized to reduce useless samples and unnecessary measures
- The geostatistical approach, which provides consistent estimates and reliable maps, is an appropriate solution for data analysis

Introduction

- The active culvert at Studsvik was built 1957 – 62, and most of the system has been in continues use to support the nuclear facilities at Studsvik ever since
- The active culvert project includes sections that will be
  - renovated, resp.
  - decommissioned

Active culvert decommissioning

Objective

- The objective with the radiological survey of the active culvert is to obtain information about the radiological status in the active culvert
- The information is then used for
  - planning for the continued work
  - radiation protection effort
  - development of preliminary dose budget
  - waste characterization, and
  - as input to the cost estimation

Active culvert decommissioning

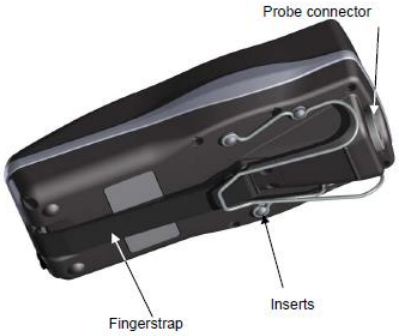
Principal layout

Map not available for general publication

Active culvert decommissioning

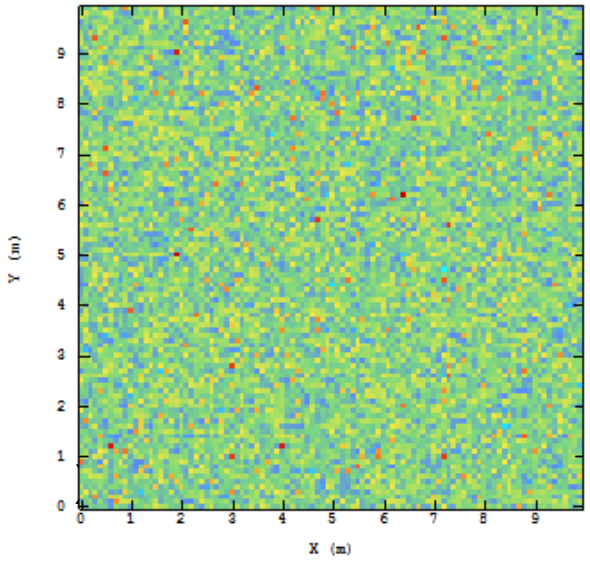
Experimental

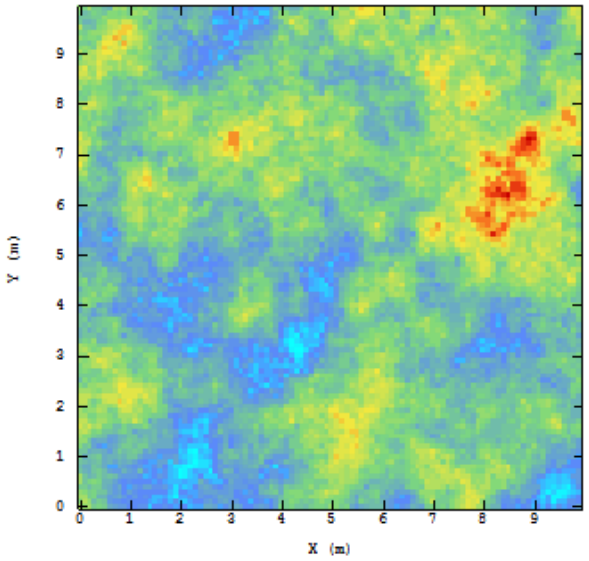
- Sampling
  - Water samples
  - Material samples
  - Smear tests
- In-situ measurements
  - Dose rate
  - Scintillation
    - 0.5 x 0.5 m
    - Full coverage by 4 x 8 alpha + beta/gamma data pairs
    - Canberra Colibri with probe Canberra SABG-100
- Data base SVALA used for the results and the measurments

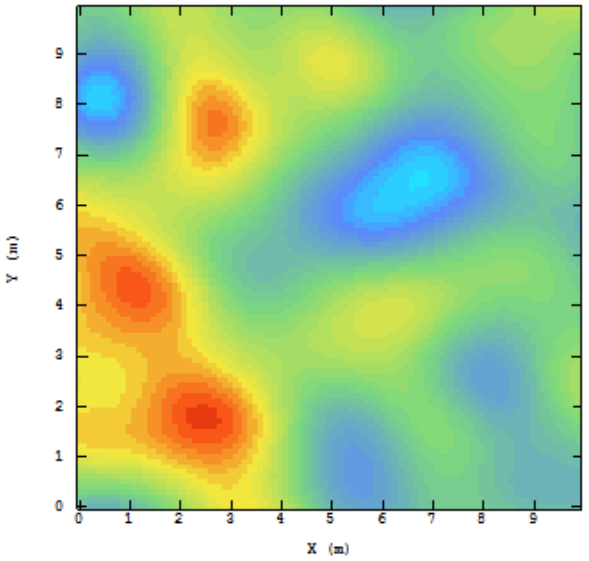


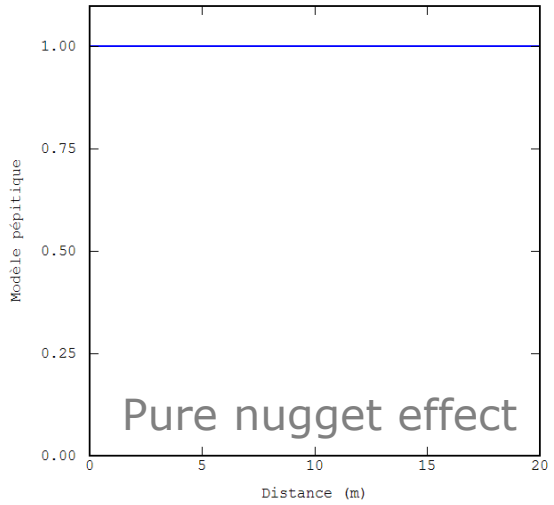
Geostatistics

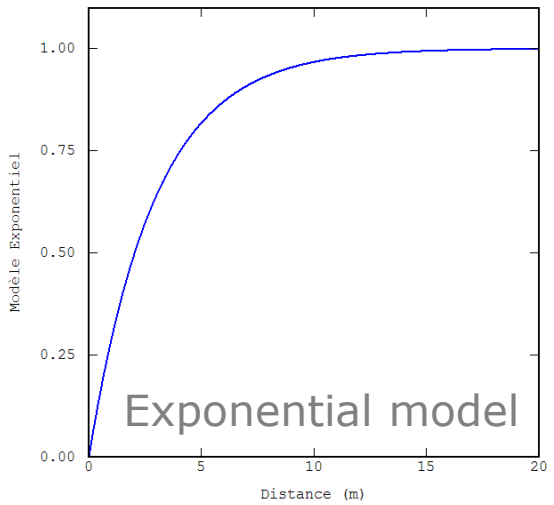
Based on the phenomenon spatial structure

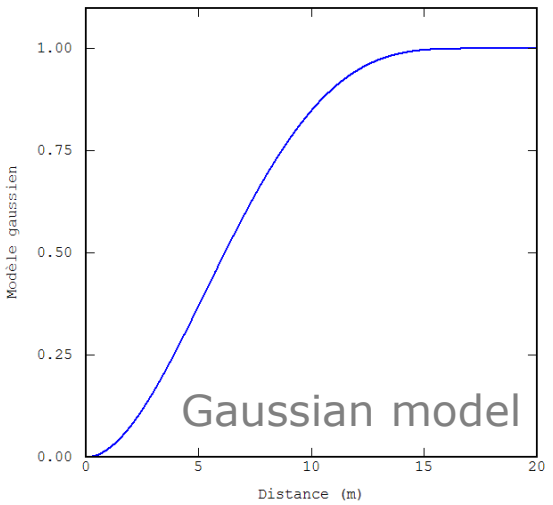












Geostatistics

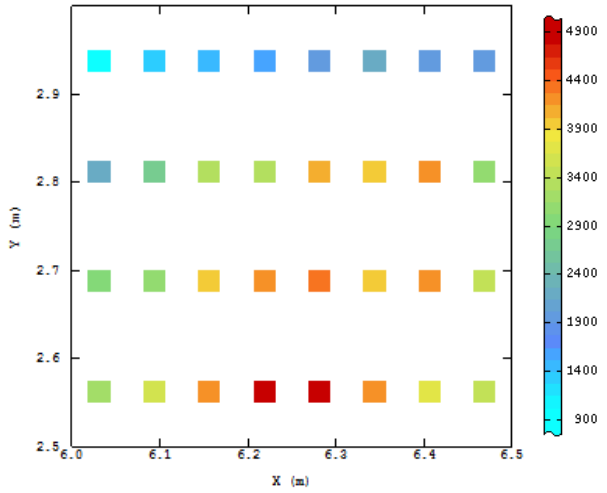
Active culvert data

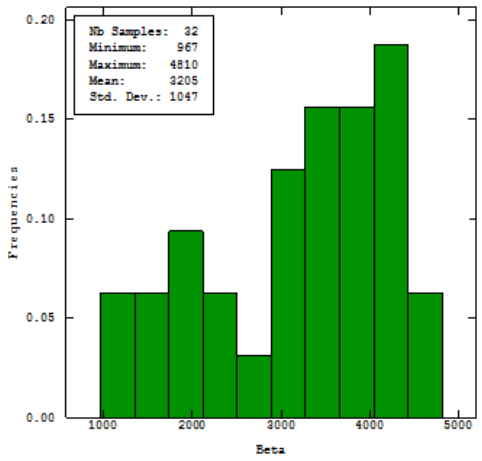
42 (0.5 x 0.5 m) areas

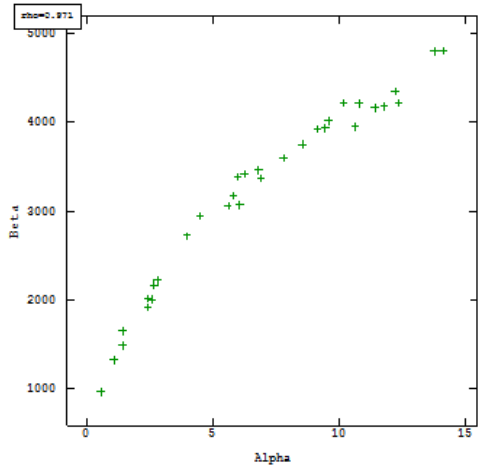
Exploratory analysis
(histogram, scatter plot)

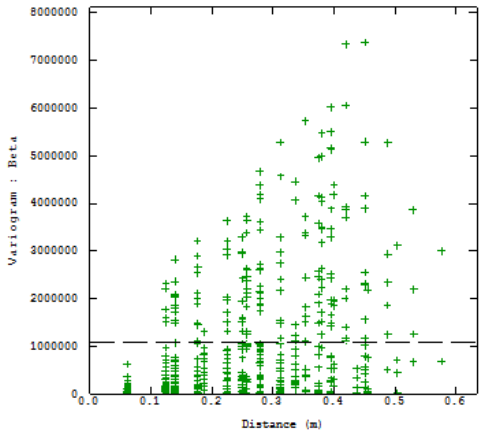
Variographic analysis

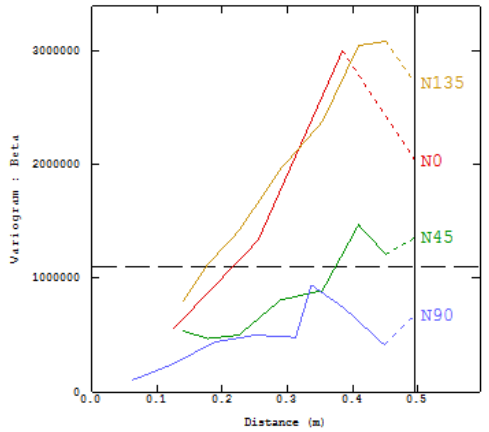
- Variographic cloud
- Directional variogram
- Non-stationnarity











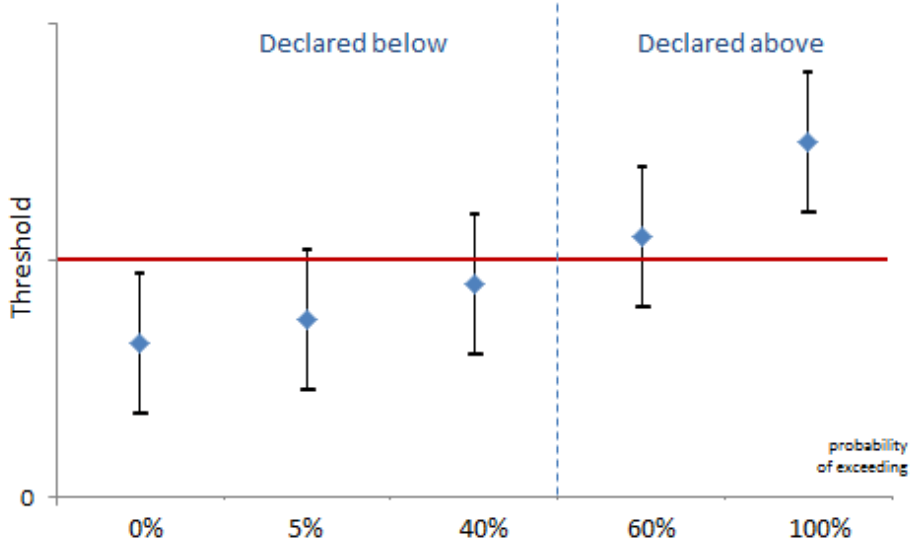
Geostatistics

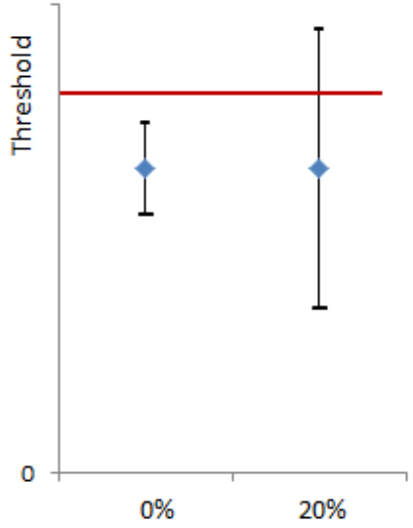
Estimation and uncertainty quantification

Interpolation by kriging (best linear unbiaised interpolator)

Uncertainty quantification

- Undersampled or high variability areas
- Probablity of exceeding a threshold





+ Advanced: non-stationnary, non-linear, multivariate...

Geostatistical

Synthetic example

A spatial simulation considered as ”real contamination”

- Total length is 1,000 meters
- Dose rates regularly spaced every 50 cm
- Samples are collected every 20 m for activity levels

A unique decision threshold for metal classification

Geostatistical

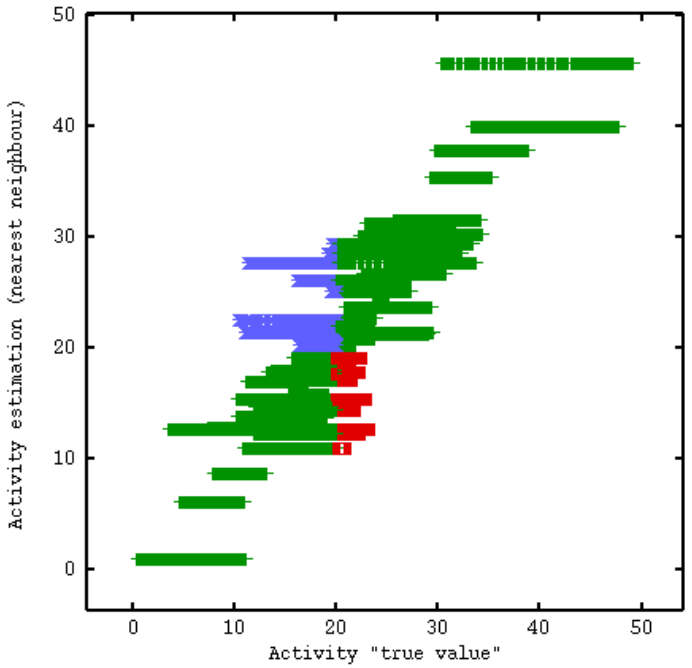
Synthetic example

"Real" length above the threshold: 494.6 m

Deterministic method: nearest neighbour

Total of 500 m are declared above the threshold but:

- 453.6 m are correctly classified
- 46.4 m are false positive
- 41.0 m are false negative



Geostatistical

Synthetic example

Monovariate and multivariate geostatistics

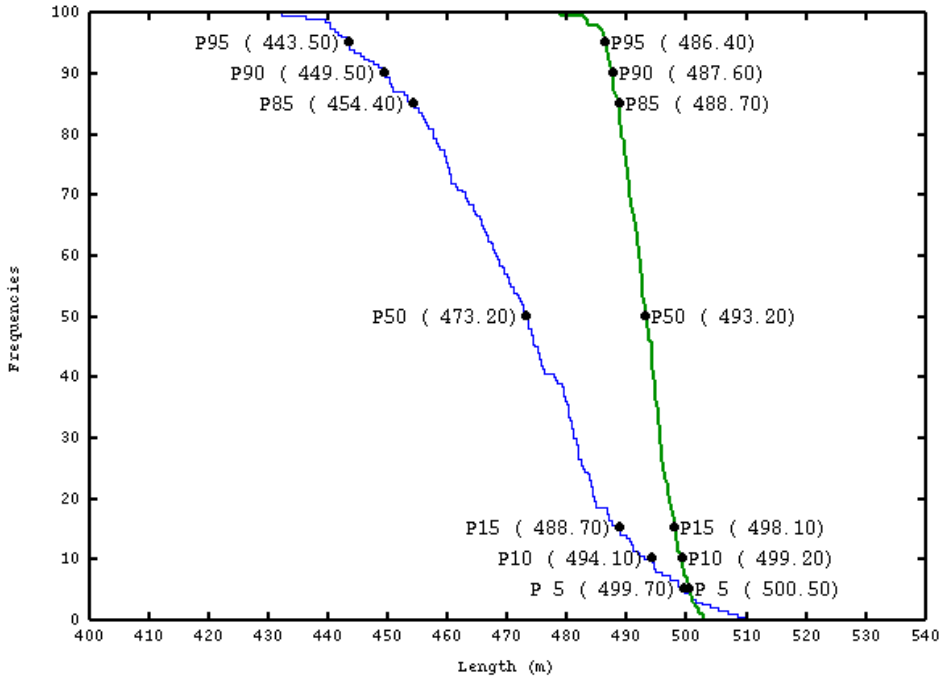
On the basis of
cokriging results:

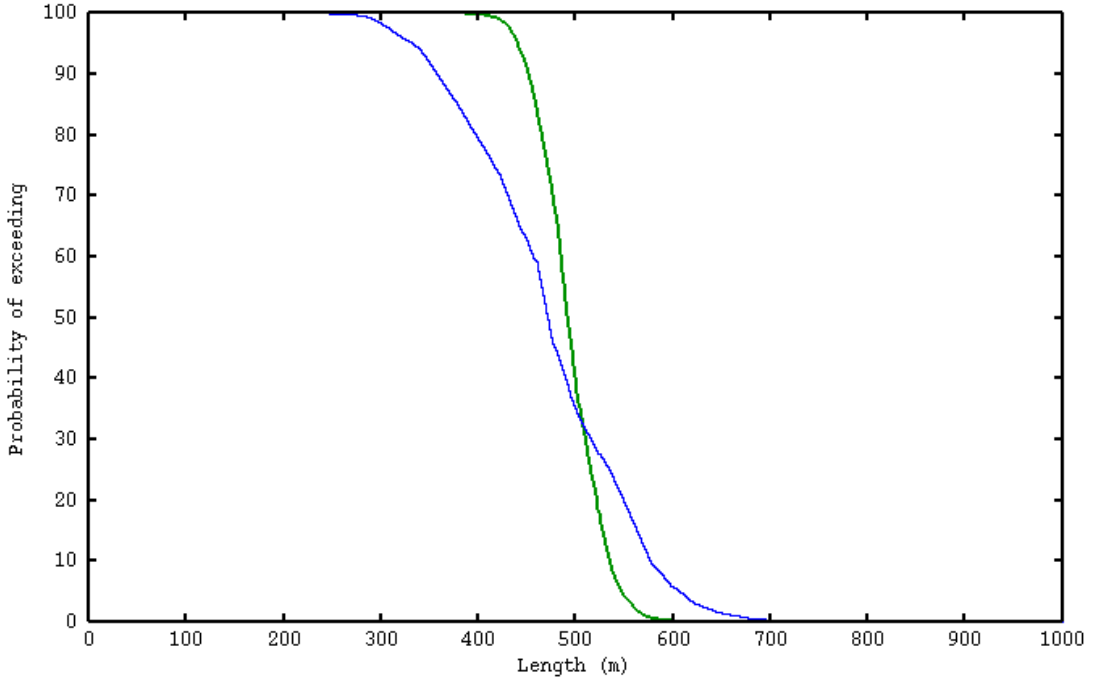
- 483.1 m are correctly classified
- 1.1 m are false positive
- 11.5 m are false negative

Geostatistical

Synthetic example

Global and punctual estimates





Uncertainty reduction integrating dose rate values

Conclusion

- A radiological survey has been performed in the active culvert at Studsvik, due to a planned decommissioning
- Parts of the metal piping network is difficult to access due to non-viable sections
  - Alternative survey methods are needed
- Geostatistics proves to be a relevant data processing technique for a better characterisation of contaminated materials
  - Metals in particular
  - Leads to a better segregation for clearance, recycling, reuse or waste minimisation

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