COMPARATIVE ASSESSMENT OF GEOSTATISTICAL TOOLS: A SUDBURY CASE STUDY

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Outline

- Introduction
- The dataset
- Geostatistical Concepts
- Results
- Future Work
- Conclusions

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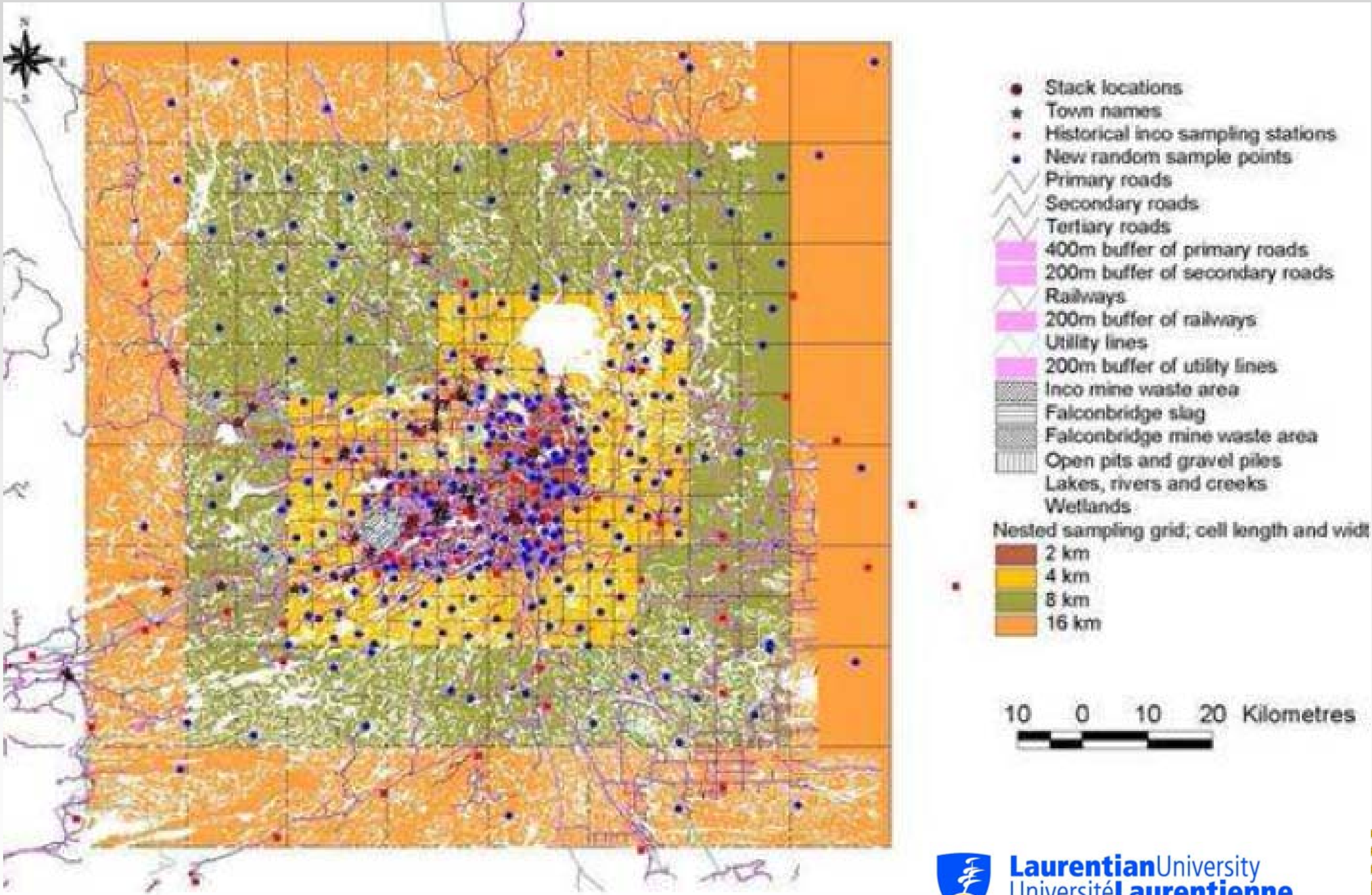
Introduction

- Soil sampling reflects the total historical metal accumulation from point sources
- Sampling, analysis and interpretation are required for future developments in ecological and human risk assessment projects
- Fundamental question: How to use limited information efficiently?

The dataset (1)

- A nested sampling grid, covering an area 200 km by 200 km
- Centered on the three smelters, Copper Cliff, Coniston and Falconbridge.
- The centroid was in the vicinity of the Copper Cliff smelter.
- Stratified sampling: cells were 2, 4, 8 and 16 km square
- Sampling exclusion zones were defined

The dataset (2)



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Geostatistical Concepts (1)

- Dissimilarities are measured through the experimental semi-variogram:

$$\gamma^*(\vec{h}) = \frac{1}{2n_{\vec{h}}} \sum_{\alpha=1}^{n_{\vec{h}}} \left(Z(\vec{x}_\alpha + \vec{h}) - Z(\vec{x}_\alpha) \right)^2$$

- Relation between semi-variogram and covariance:

$$\gamma(\vec{h}) = C(\vec{0}) - C(\vec{h})$$

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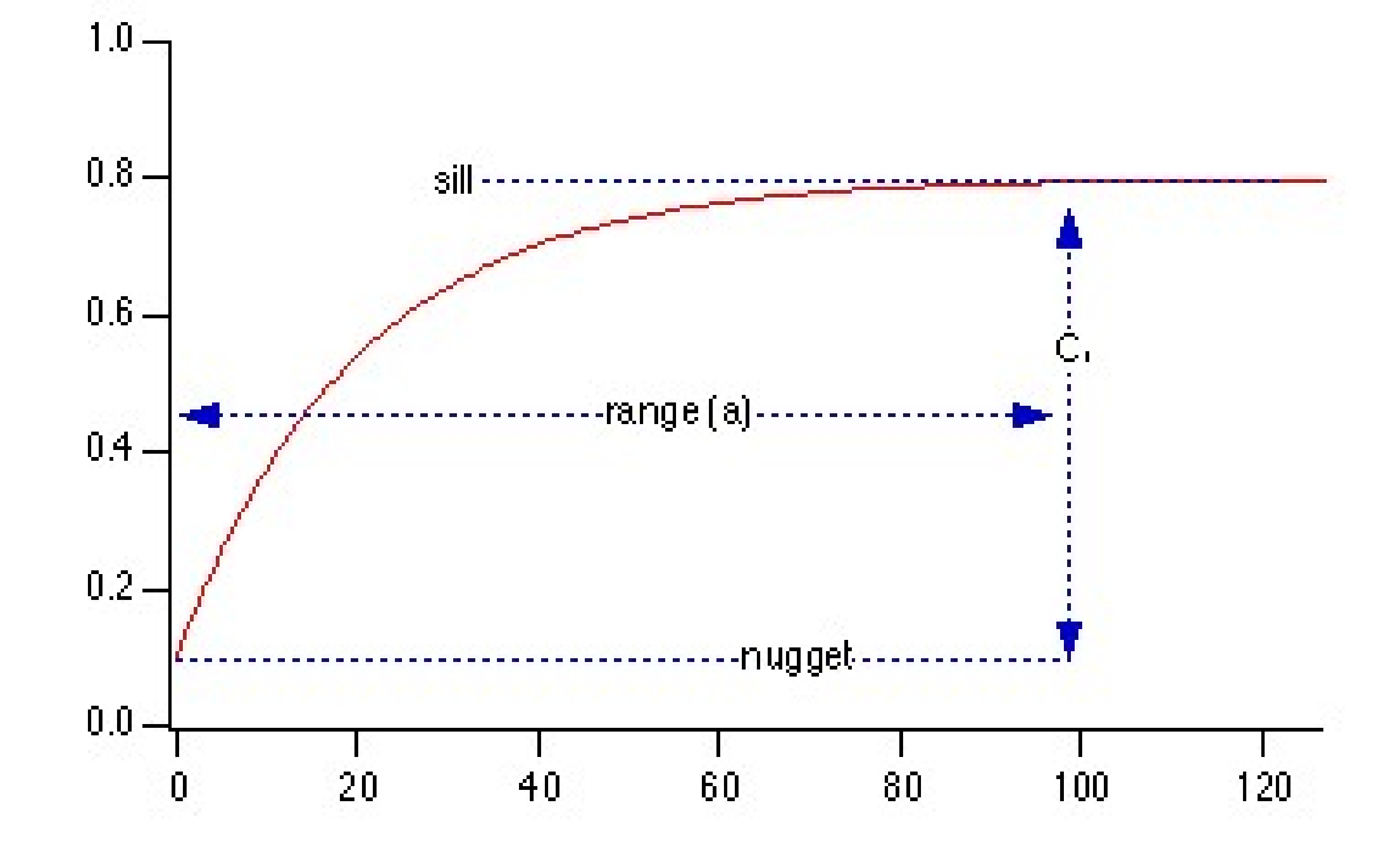
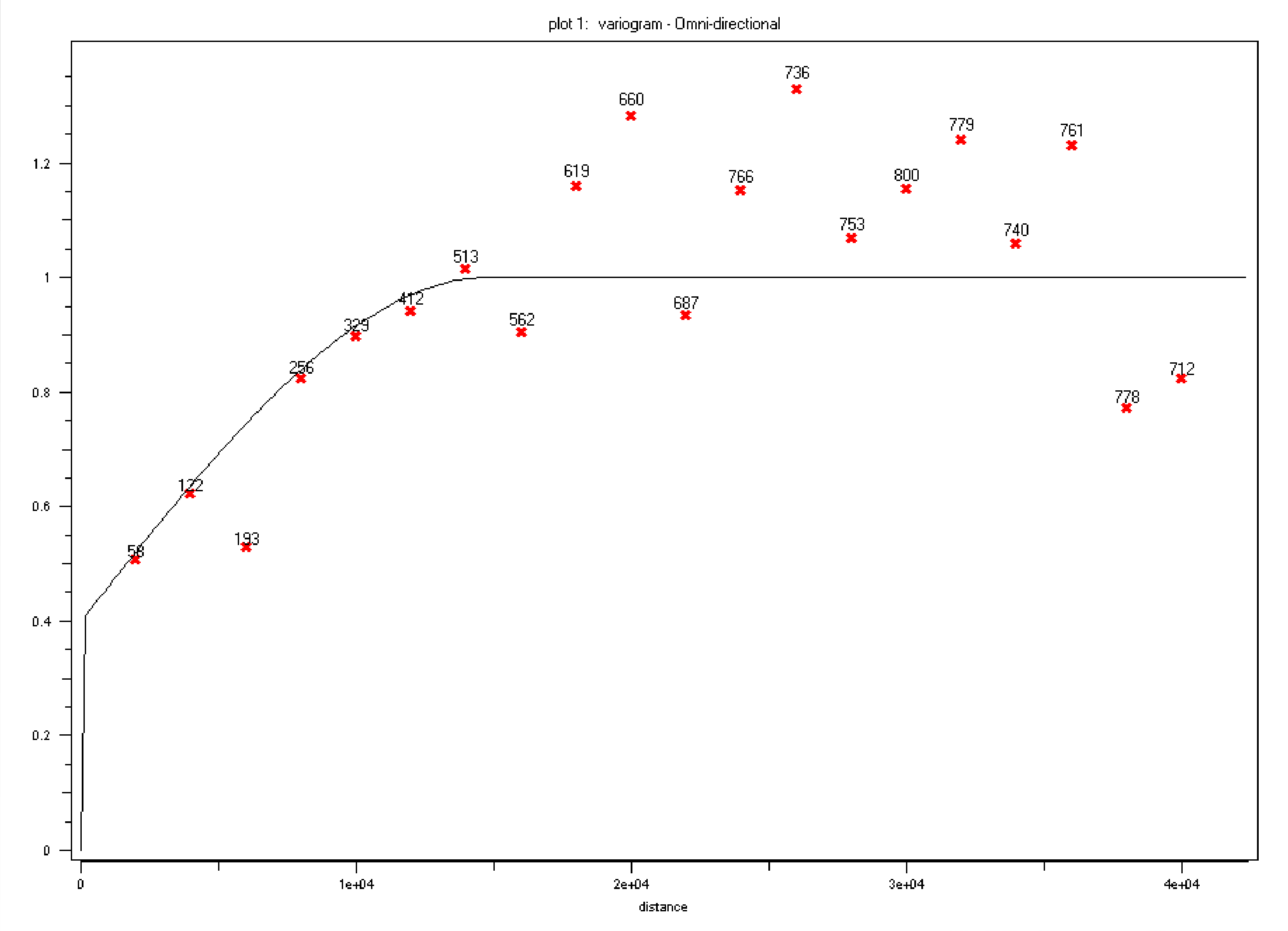
Geostatistical Concepts (2)



(http://www.wavemetrics.com/)

Variogram Fitting



Geostatistical Concepts (3)

- Kriging:

$$Z(\vec{x}) = \sum_k \lambda_k Z(\vec{x}_k)$$

- Sequential Simulation:

$$f(x_{\sigma(1)}, x_{\sigma(2)}, \ldots, x_{\sigma(n)}) = f(x_{\sigma(n)} | x_{\sigma(n-1)}, \ldots, x_{\sigma(2)}, x_{\sigma(1)}) \cdots f(x_{\sigma(2)} | x_{\sigma(1)}) \cdot f(x_{\sigma(1)})$$

- Difference in Variance:

$$\sigma_S^2(\vec{x}) = 2\sigma_E^2(\vec{x})$$

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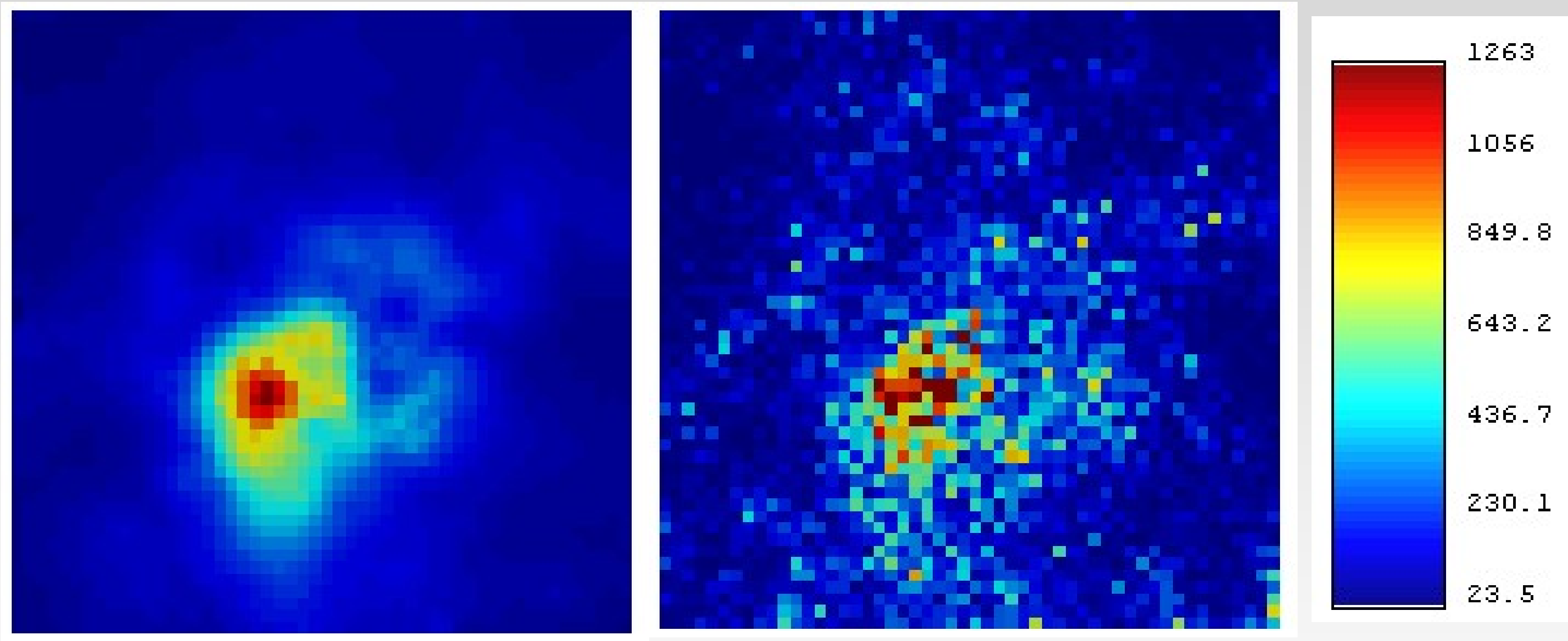
Results (1)



Kriging **Simulation**

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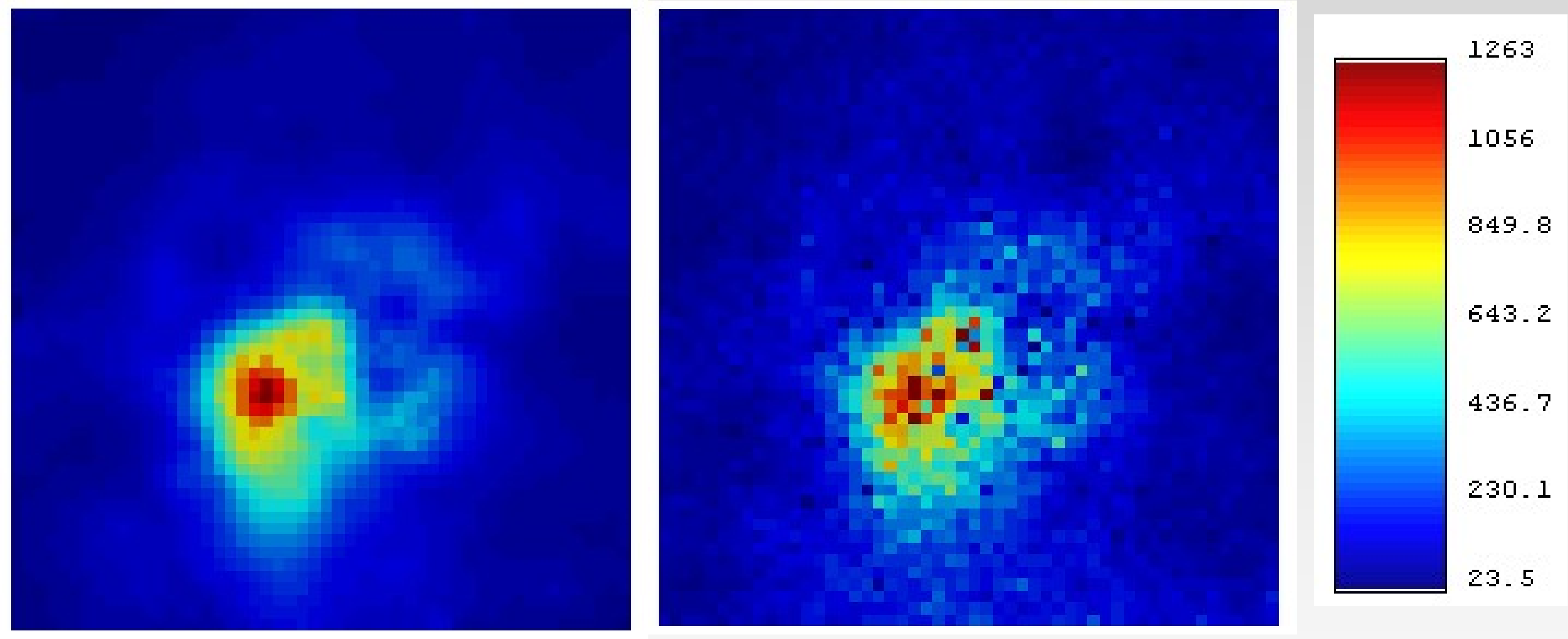
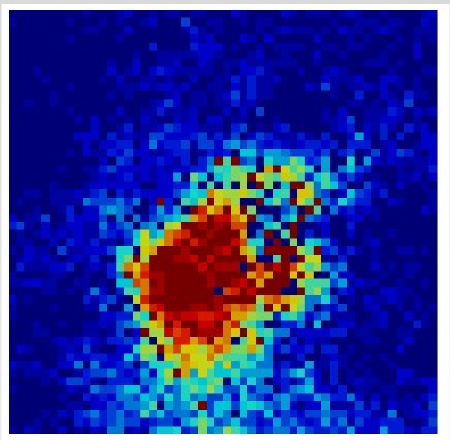
Results (2)

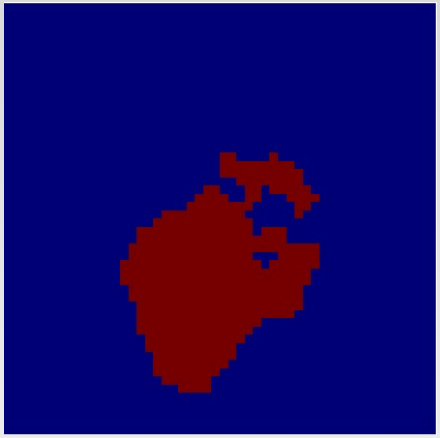


Kriging **E-Type**

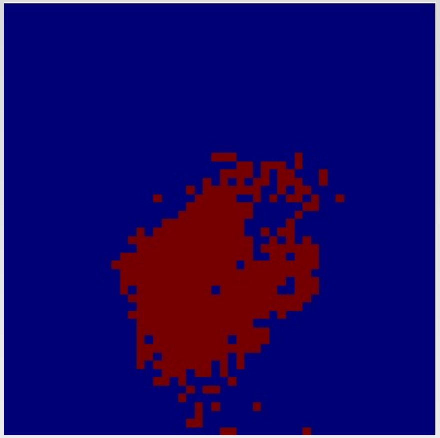
Results (3)



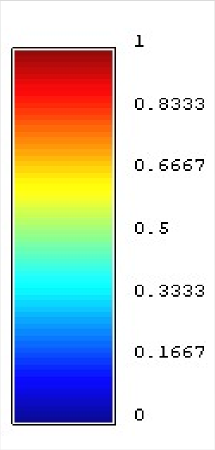
Probability Map



Kriged values above 250 μg/g



E-Type values above 250 μg/g



Results (4)

- A cell will be declared “contaminated” if Ni level exceeds 250 μg/g (MOE: 200 μg/g)
- Using Phytoremediation on the top 5 cm (each cell has 200000 cubic meters):
  - Kriging: $1,197,000,000 for full remediation
  - E-Type: $1,227,000,000 for full remediation
- Problem: Kriging and E-type don’t represent correctly spatial variability and don’t provide a good assessment of risk involved

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Results (5)

- Probability map provides risk profile at each cell:
  - Risk level of 50%: at least $216 million, or approximately 18% cheaper.
  - Risk level of 25%: at least $552 million, or approximately 46% cheaper.

Future Work

- Given a budget constraint. Which remediation decision will maximize the expected benefits?
  - Not feasible to rehabilitate all the cells
  - Focus on more probable contaminated cells
  - Stochastic resource allocation problem

Conclusions

- Standard spatial interpolation techniques tend to overestimate the metal contents within the soil case study example investigated
- Simulation has potential for providing the probabilistic distribution of metals within the soil, thereby improving the decision making process
- Differences in risk level of up to 45% are observed when considering rehabilitation measures

Thanks!

Questions are welcome…