Application of geostatistics to determine the environmental accountability regarding organic soil contaminations

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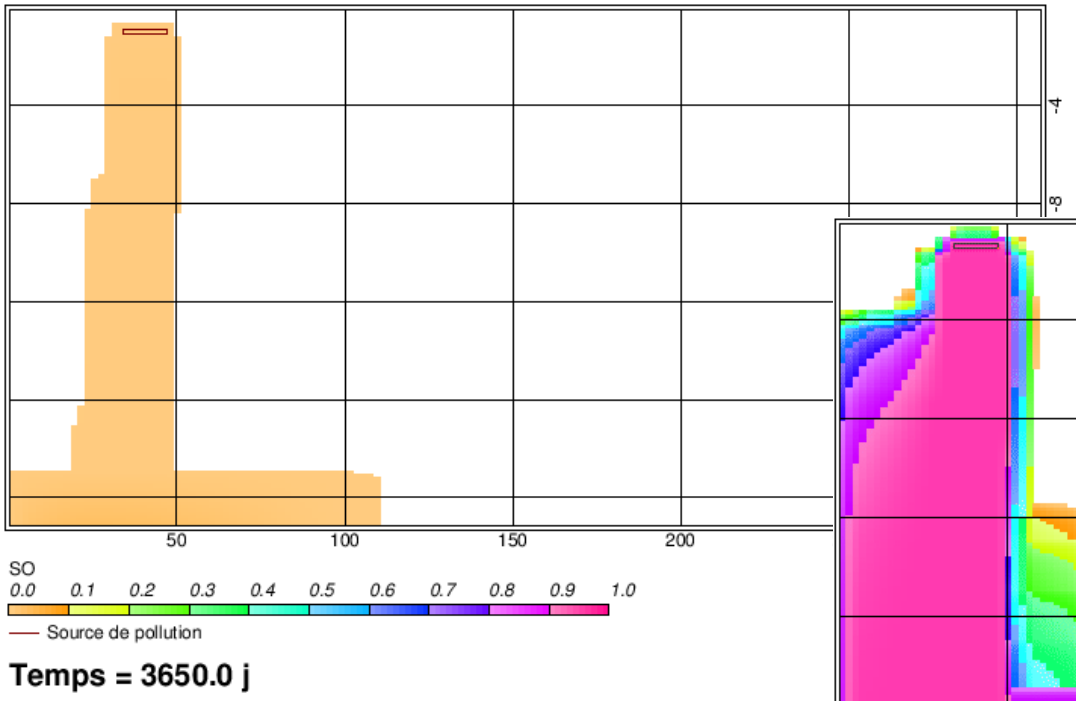
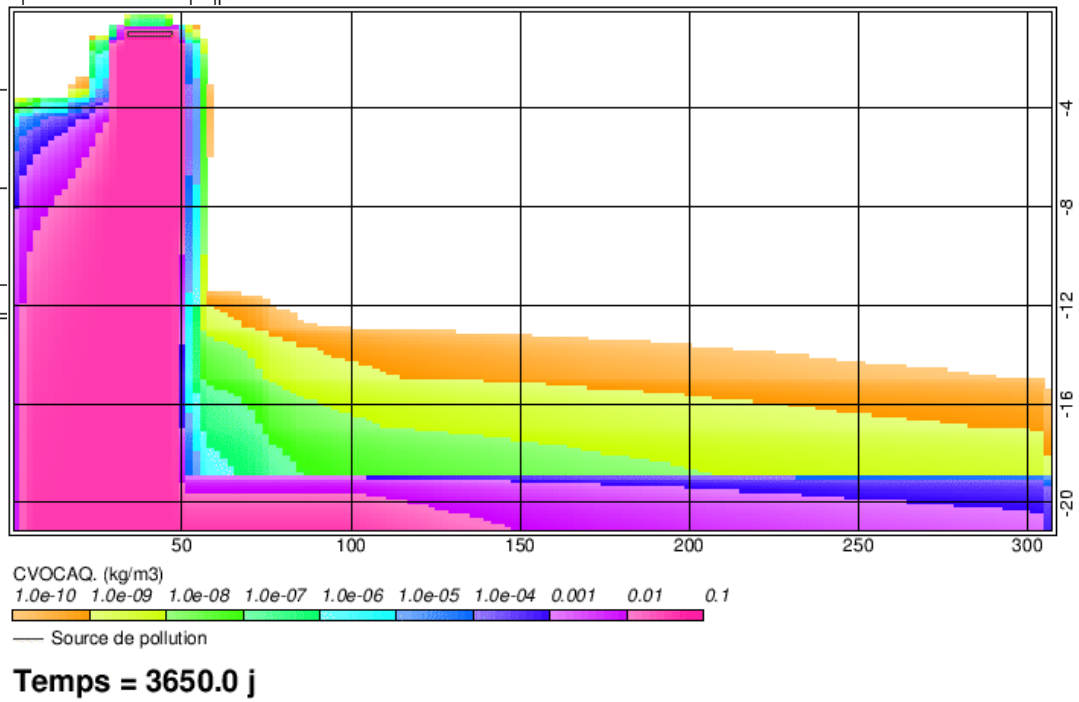
KIDOVA
Knowledgeable & Imaginative Visions

Environmental accountability issue

Today observations of soil and groundwater contaminations



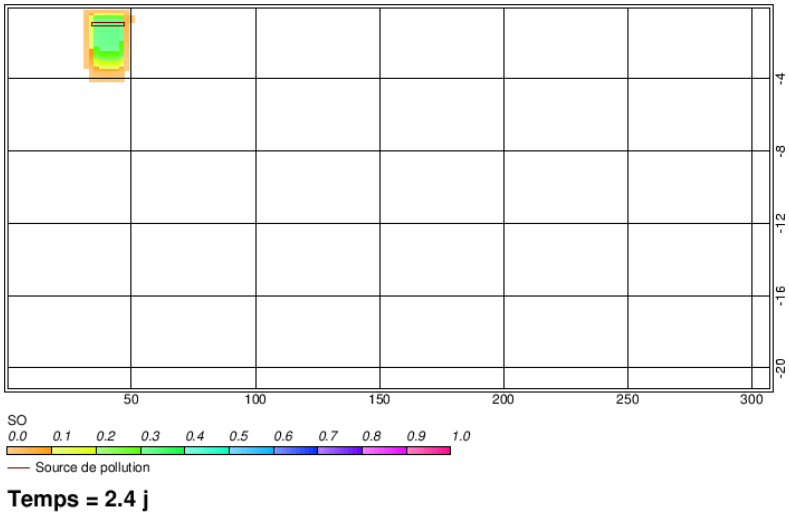
Soil contaminant saturation



Groundwater contamination concentration

Environmental accountability issue

QUESTION: identifying the locations of original sources hence identifying the environmental accountability of the contamination



- Based on sparse data that provide information about the soil contamination in its current state
- By distinguishing somehow contaminant migration pathways from groundwater-transported contamination

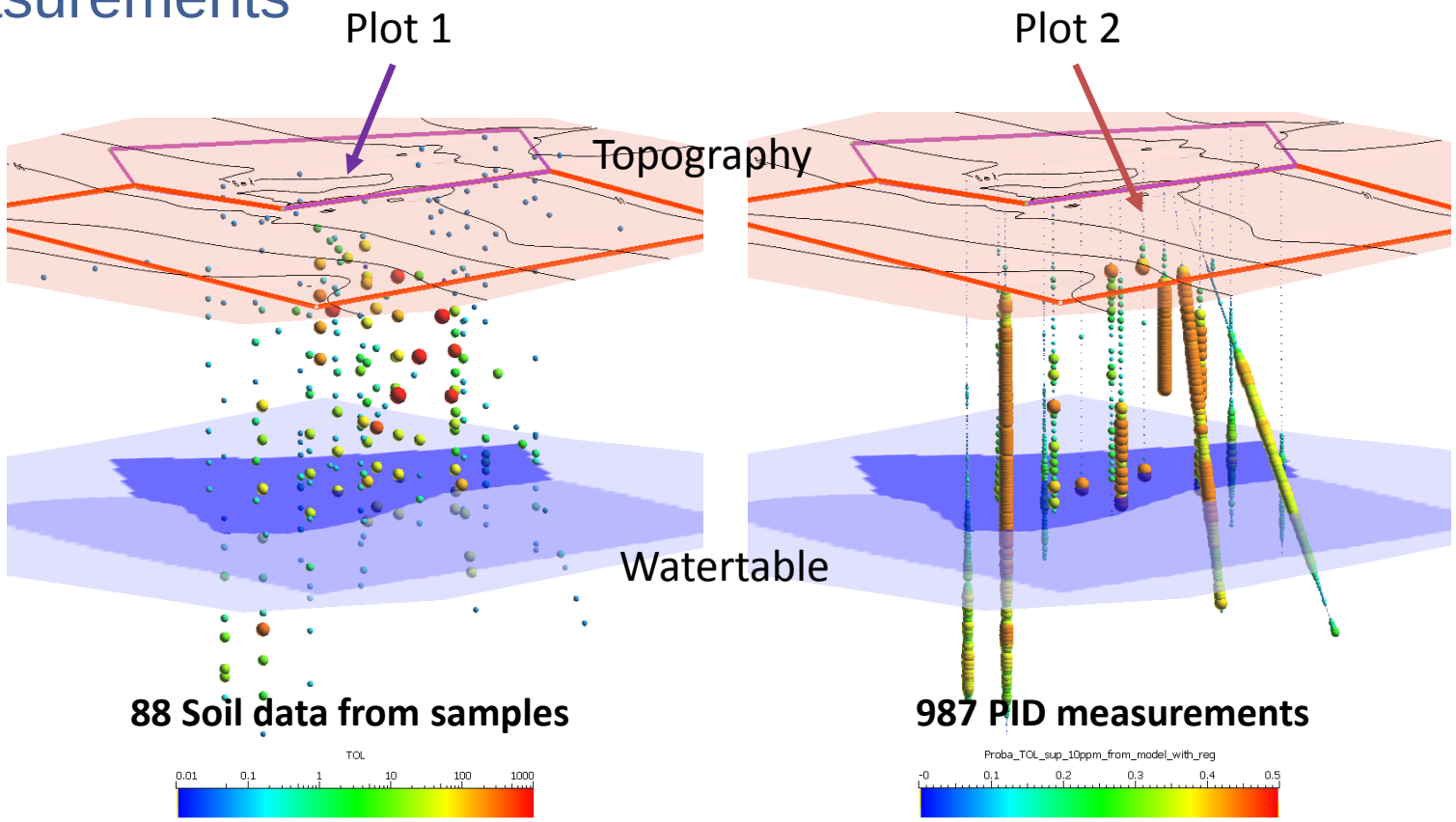
Proposed approach

- Objectives
  - Determining relevant contaminant grade thresholds that can be associated with **contaminant migration pathways**
  - Identifying the **contaminant migration pathways** as corresponding to high enough probabilities of exceeding the threshold

- Methodology
  - Use of geostatistics for estimating the probability of exceeding the contamination threshold
  - Available data
    - Contaminant grade (direct comparison between grade and threshold)
      - **If grade > threshold then Proba = 1, otherwise Proba = 0**
    - PID measurements (indirect comparison between grade and threshold)
      - **Probabilities derived from the relationship between grade and PID data**

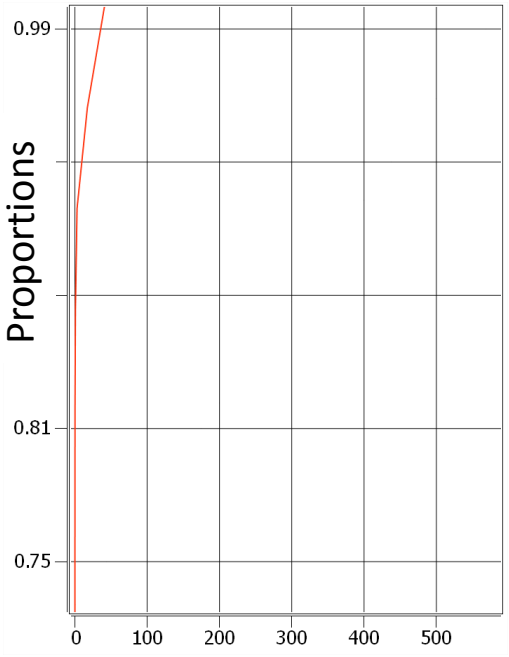
Case study

- Site divided into 2 plots
- Multiple contaminants: toluene, benzene, alcohols, …
- Available data: lab contaminant grades and onsite PID measurements

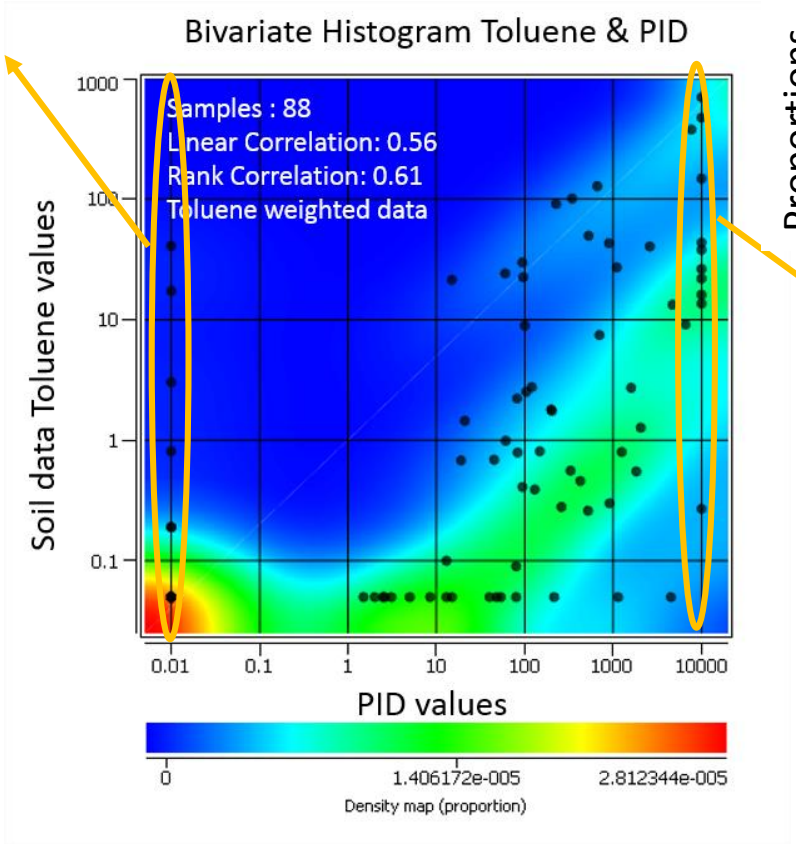


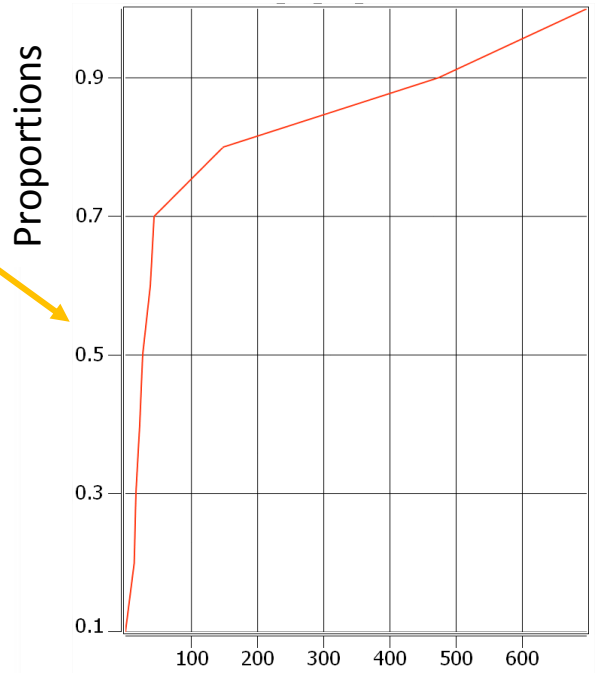
Relationship between PID and grade data

Use of bivariate histogram models to account for complex (nonlinear) relationships



Toluene cumulative histogram for PID = 0.01



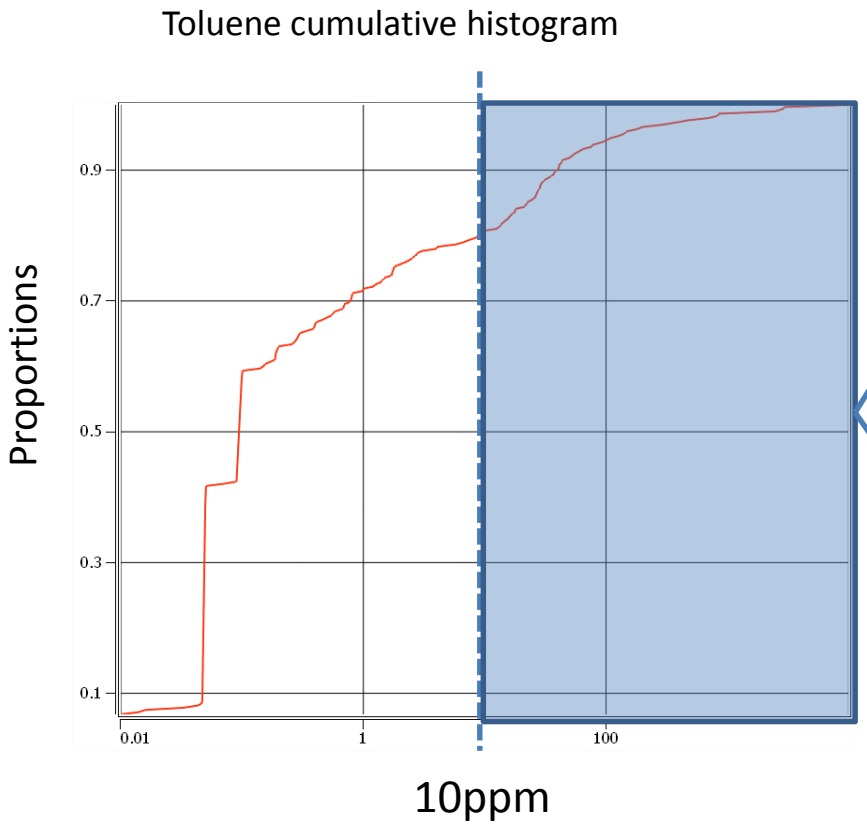


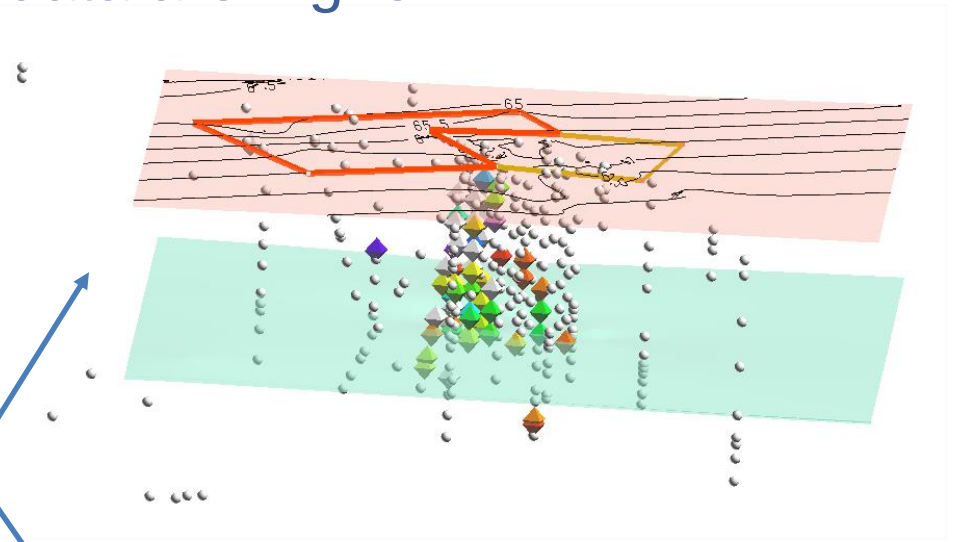
Toluene cumulative histogram for PID = 10,000

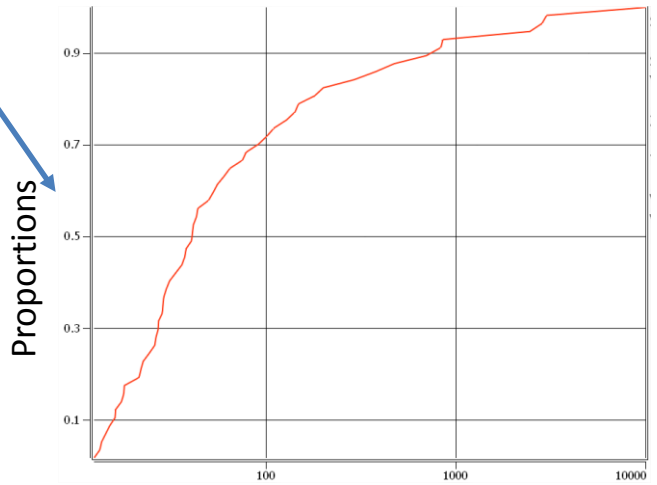
Deriving the distribution (histogram) of contaminant grades from PID measurements

Selecting a grade threshold

Threshold of 10 ppm: 57 grade data are higher

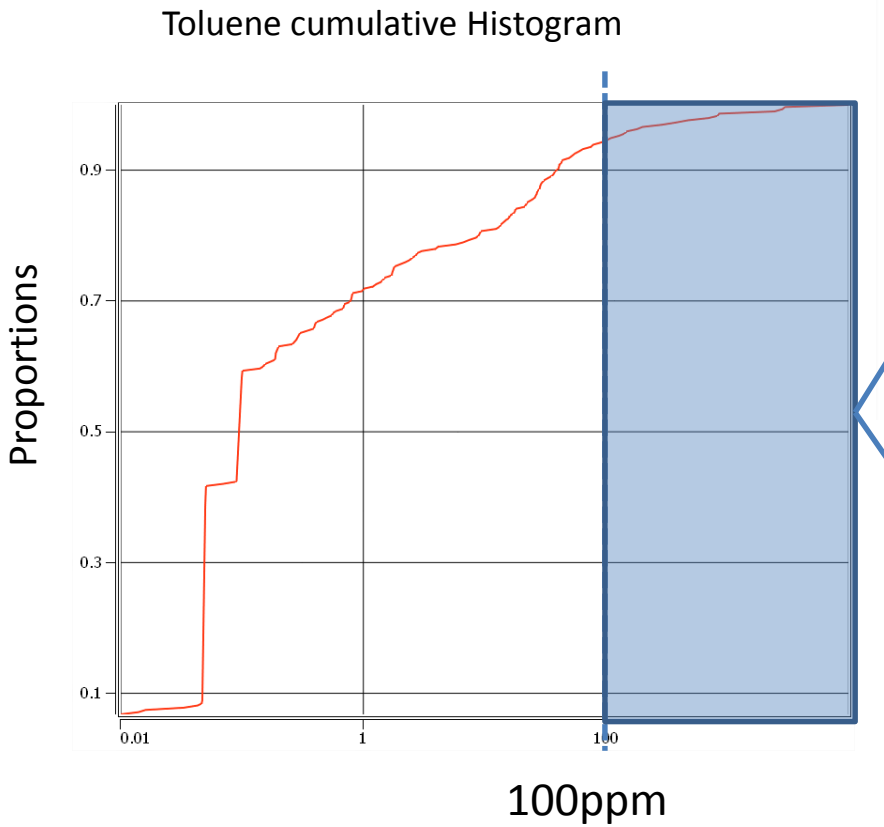


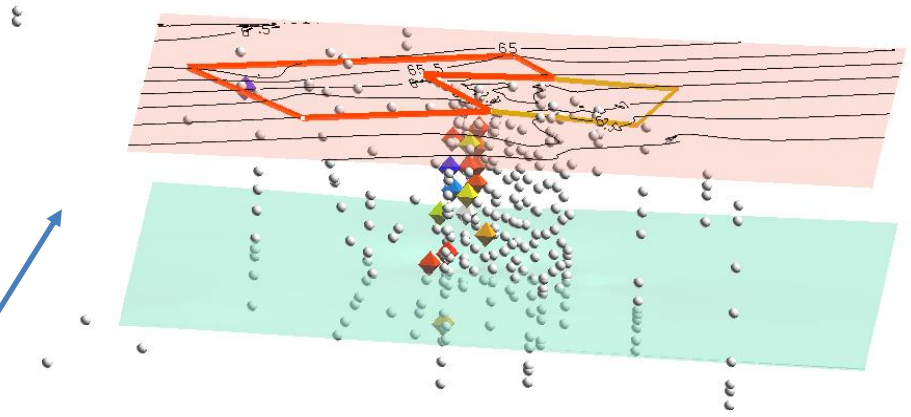


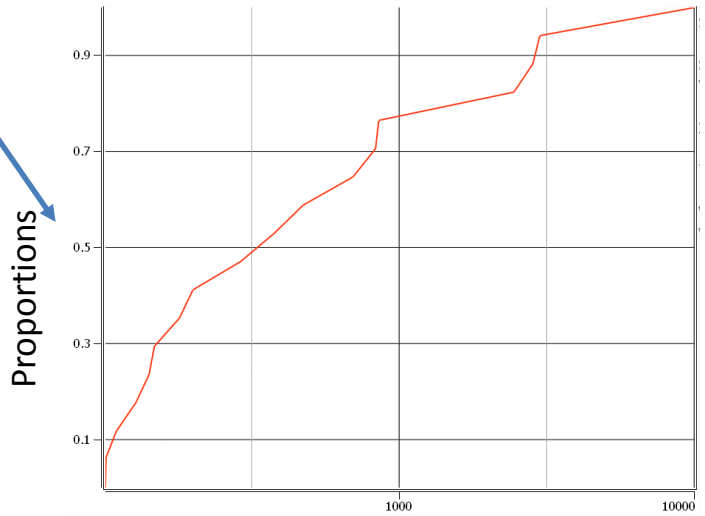


Selecting a grade threshold (cont.)

Threshold of 100ppm: 17 grade data higher





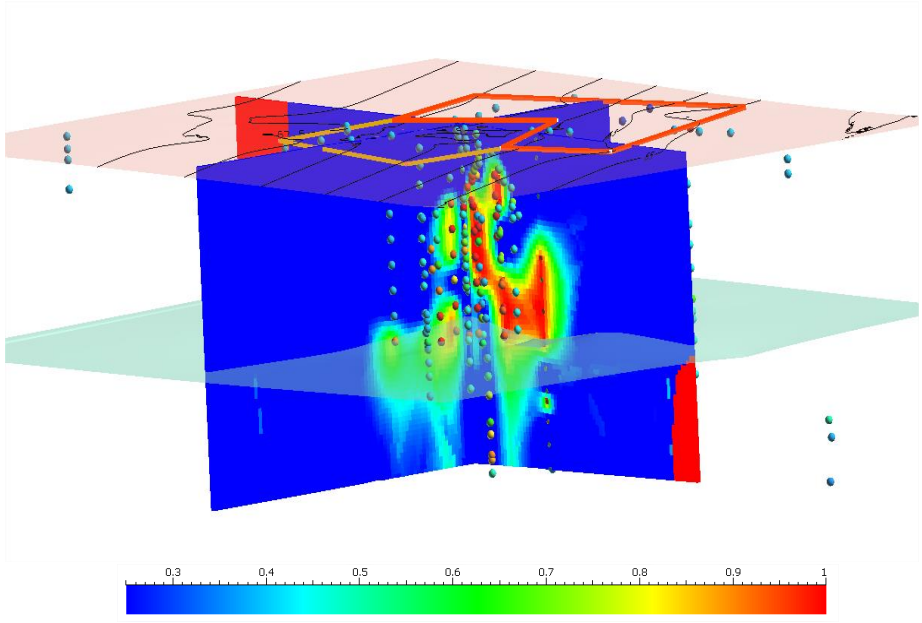


Toluene cumulative Histogram (>100ppm)

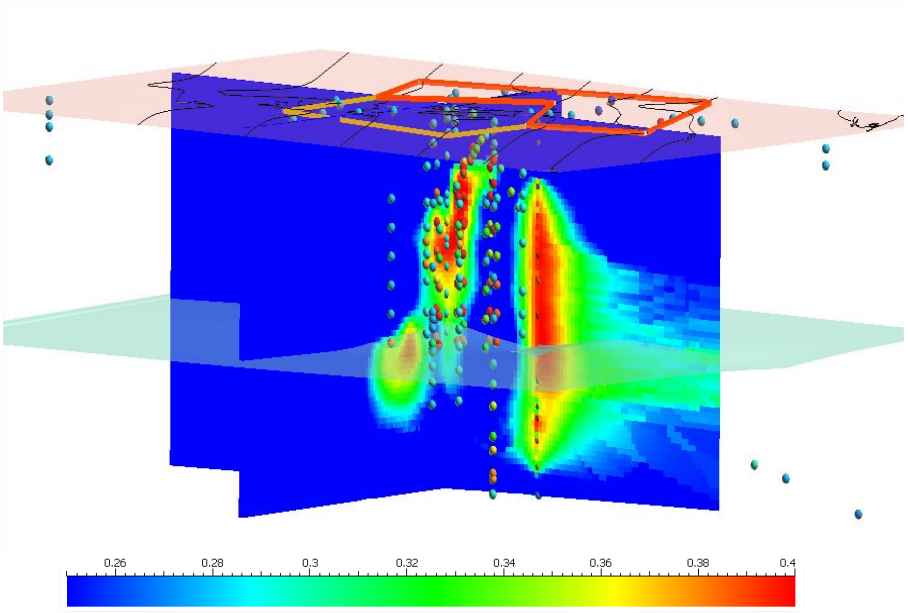
Estimating a probability map

Probability that contaminant grade > 10ppm

- Estimation by kriging (geostatistical method) from the probabilities of exceeding the threshold derived from the grade or PID data



Directly from grade data

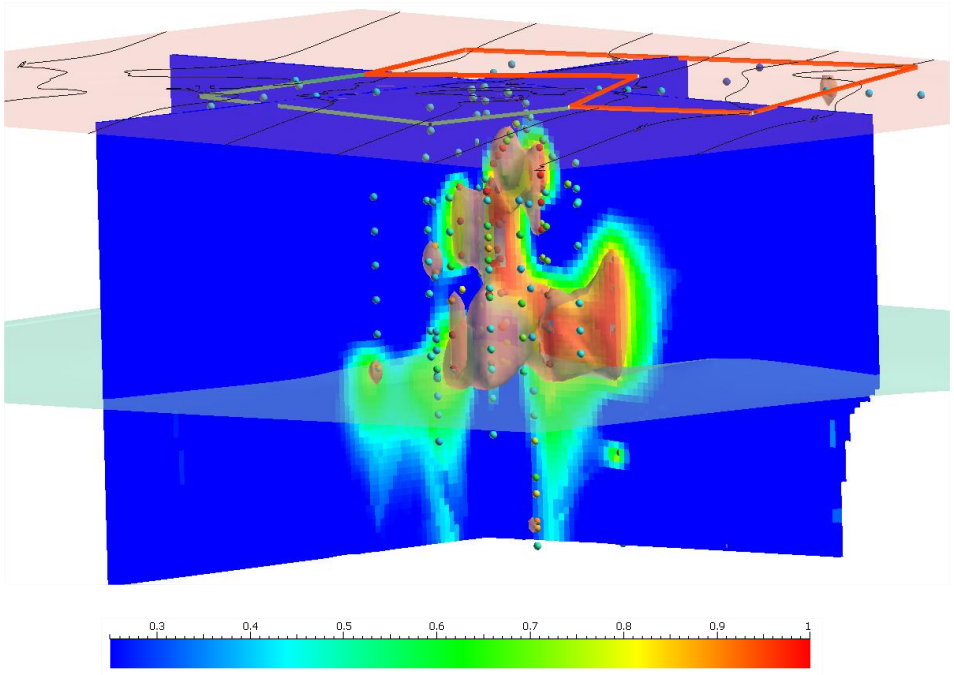


From PID measurements and the relationship with grades

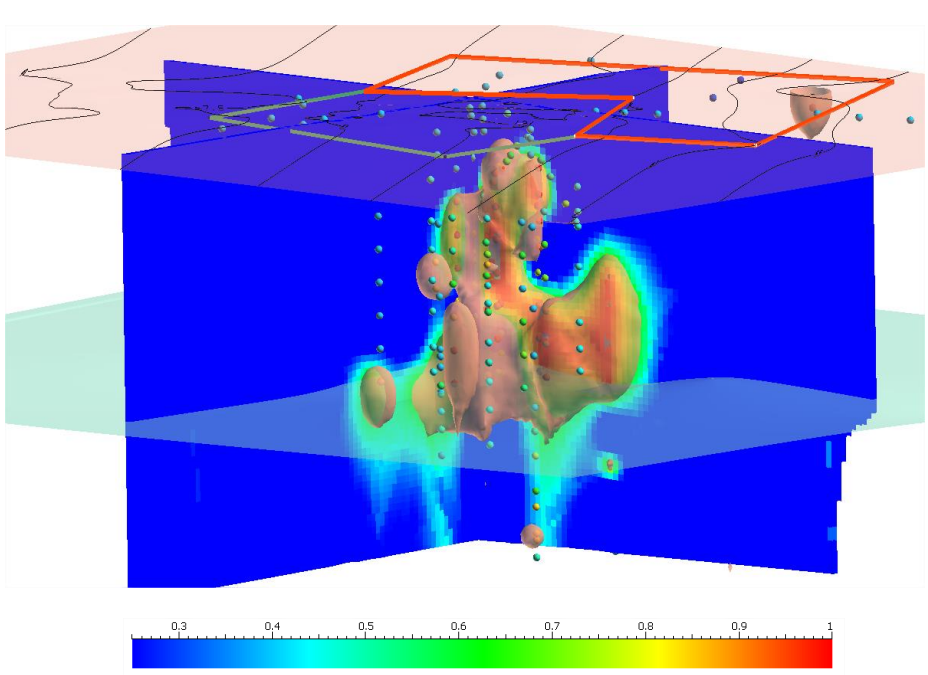
Identifying contaminant pathways

Contaminant pathways associated with high enough probabilities that contaminant grade > contaminant threshold

- Sensitivity analysis on probability cutoff



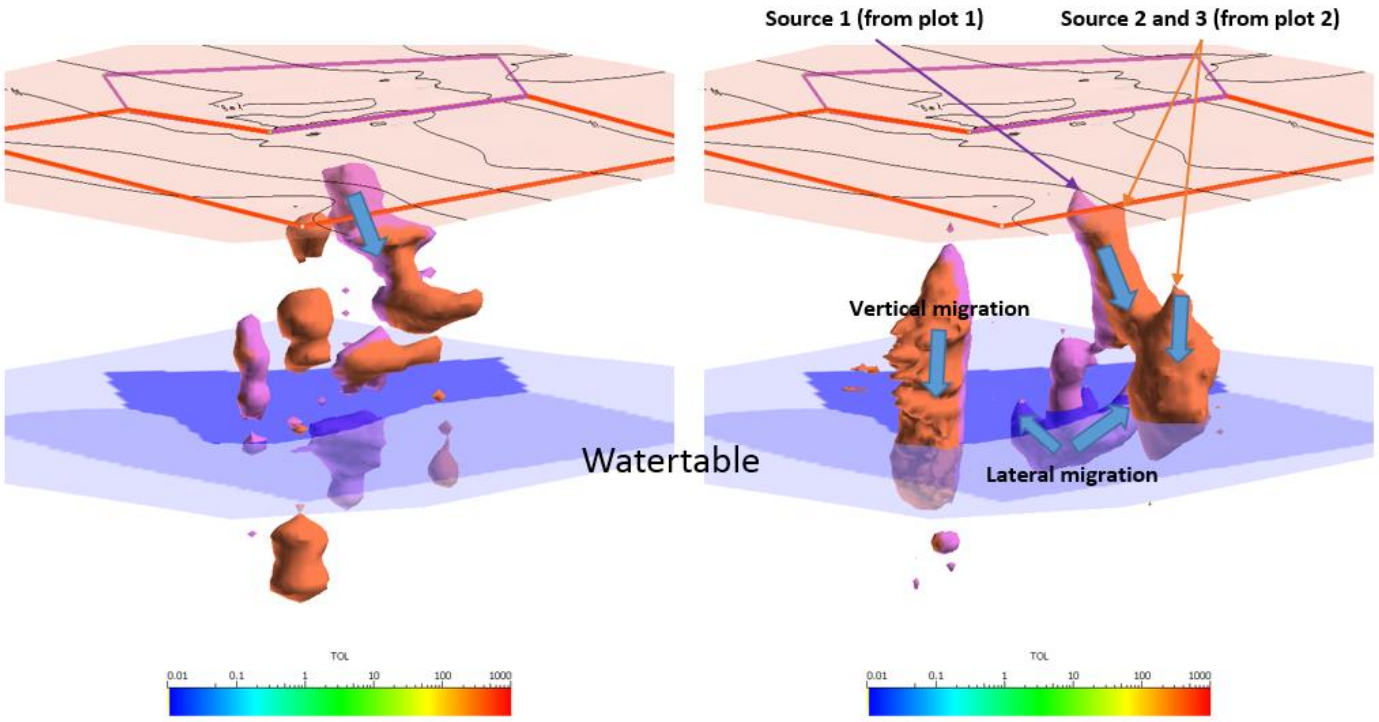
Probability cutoff = 80%



Probability cutoff = 70%

Interpretation

- Recognizing contaminant pathways
  - Vertically due to gravity
  - Horizontally due watertable and groundwater flow
- Identifying the potential contamination source locations and accountability



Right: Contaminant pathways based on toluene grade data by applying a probability cutoff of 80%

Left: Contaminant pathways based on PID data by applying a probability cutoff of 30%.

Key & critical steps of the approach

- Sensitivity analysis on soil contaminant grade threshold based on:
  - a good understanding of the contaminant migration process
  - exploratory and statistical data analyses to identify populations of contaminant grades that can be related to contaminant pathways
- Choice of estimation (kriging) parameters
- Sensitivity analysis on probability cutoff (pathway extraction)
- Checking the consistency of the results by repeating the approach with other contaminants

➔ Most contaminants of the presented case study show similar pathways and sources

Conclusion

- Consistent qualitative analysis approach
  - Providing graphic results
  - Helpful for understanding soil contaminations
  - Useful for communication purposes
- Easy to understand and fast to implement approach
  - Simple exploratory and statistical analysis
  - Simple geostatistical approach
  - Simple sensitivity analyses
- Applicable to direct or indirect (PID or other) contaminant grade data