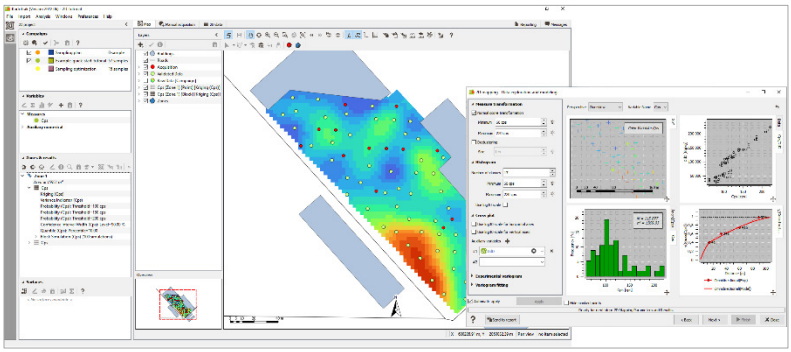
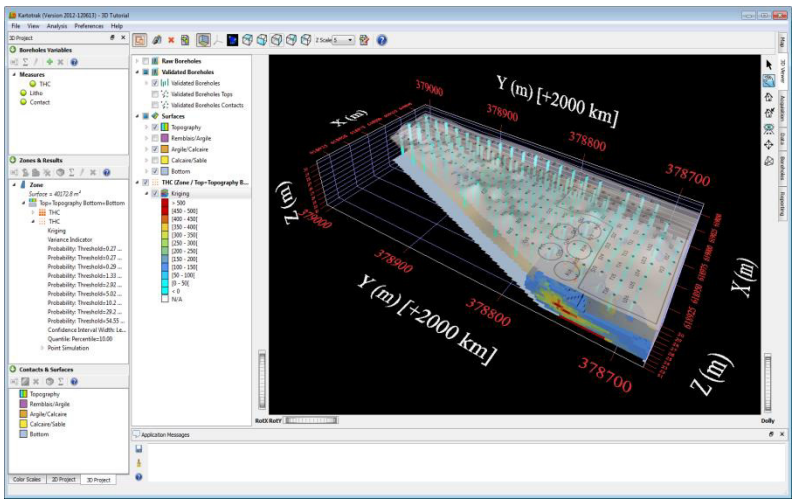
# Kartotrak Features

**Kartotrak** is an all-in-one software solution for all those involved in site remediation or nuclear decommissioning projects who need an accurate and reliable contamination (chemical or radioactive) characterization.

Based on GIS components, **Kartotrak** integrates a real-time data acquisition system, a workflow for data analysis and modeling through geostatistics), and reporting tools.

**Kartotrak's** integrated workflow enables a comprehensive approach, from sampling plan design and optimization to contamination mapping and excavation plan delivery, through remediation volume and mass quantification and risk assessment.






## KARTOTRAK WORKFLOW

**Preparation of the sampling campaign**
Delineation of target areas

**Preliminary sampling plan**
Mesh definition, control of resolution and orientation

**Data acquisition**
On-site real-time data acquisition or file import

**Data validation**
Detection limits and duplicates management

**Data analysis**
Delineation of target geological layers, statistical and spatial analysis, variography

**Estimation and mapping**
Calculation of kriging and variance maps

**Risk assessment**
Delivery of probability, quantile and confidence interval maps

**Areas/Volumes & Excavation**
Quantification of soil volumes/areas and masses to be treated considering one or several remediation thresholds or using a Pareto approach, remediation efficiency evaluation according to the risk of leaving contaminated lands, calculation of excavation plans

**Visualization of results**
Identification of areas requiring further action (under-sampled areas, hot spots, etc.)

**Reporting**
Report creation as the project is built

**Sampling optimization**
Locate additional samples by defining an optimization criterion and a number of points

# 1. GIS-BASED INTERFACE

- Experience Kartotrak **ease-of-use**: the software is a **GIS**-based (Geographic Information Systems) application with a global interface from which all applications are launched.
- Benefit from usual **geographical tools**. The display is organized in superimposed layers with all the attached functionalities: display/mask, add/delete, edit, move forward/backward, zoom in/out, scale, compass grid or axis scale, etc.) so that you customize the view to your own needs.
- **Additional tools enable the precise control of items**: the measure of distances between points, angles between segments, polygon surfaces, highlight/mask/edition of samples or polygons, etc.
- **Create Polygons** to delineate specific areas (facility outlines, yards, roads, area to be estimated, etc.) via file import (shp, dxf, etc.) or on-the-fly digitization. Automatic calculation of the envelope encompassing all the data used to constrain the interpolation in space. These polygons will be considered later in the modeling.
- Enrich the scene with **vector or raster images**: besides the standard image file formats (bmp, gif, jpg, png, tif), Kartotrak may load many file formats, including AutoCAD DXF, GeoTIFF, MapInfo, or ESRI Shapefile.
- Enrich your displays with **imported scanned paper maps** or Google maps and **geolocalize** them in the project.
- **Display in a table** a chosen set of information related to selected objects from the 2D map.
- Take advantage of the dynamic link between the display window and the database allowing an **automatic update** of the view with new data.
- **Customize the display** according to your **visual style guidelines**: symbol shape, color, size, color scale setting, variable filtering, isolines. Draw a line between measurement points following their acquisition order to facilitate the detection of possible GPS jumps and better interpret the measured values when the paths intersect.
- Juxtapose results from different areas inside a single view.
- **Create and share color scales** between projects.

# 2. DATA HANDLING

## 2.1. Data integration

- Fully integrate and handle **2D surface measurements** and **3D borehole data**.
- Easily import new data through **csv** or **Excel** files, or more simply, by a **fast Copy/Paste** from an **Excel file**. Variables are loaded with their units. The detection limit of devices is also saved.
- Choose the appropriate **coordinate system** among a full range of projection systems to correctly position your data on the map.
- Load **surface information (topography, lithology)** and interpolate them over the area (through inverse distance weighted interpolation, linear kriging, or spline kriging). The resulting surfaces are used to restrict the 3D mapping vertical limits or as 3D supports to drape the current GIS view over them.

## 2.2. GPS connection

- **Connect a GPS and precisely locate any point on a site**: the location is automatically marked out by a symbol on the map.

  Connection is made between the software and the GPS (with NMEA output) thanks to a specific interface.

## 2.3. Real-time data acquisition (only for 2D data)

- Experience seamless **real-time data acquisition** using Kartotrak specific interface.

  Connection is made between the software and the different measuring devices and a GPS to **acquire data in a streaming way**.

  The position of the samples being acquired and their values are automatically stored in the database (if embedded in a truck taking continuous measurements) or through a simple click from the operator.

  Kartotrak can connect with the following measuring devices:

  - All ORTEC "CONNECTIONS" products, including the mechanically cooled, integrated HPGe spectrometers: Detective, Trans-SPEC, and IDM series, and digi-BASE products for NaI spectrometry;

- CSP probes from MIRION TECHNOLOGIES (CANBERRA).
- DSP detector by SAPHYMO.

Should your devices not appear in the above list, Geovariances offers development services to interface them with Kartotrak).

### 2.4. Database

- **Differentiate variables** according to their types for proper use: coordinates, measures, auxiliary numerical variables, auxiliary categorical variables, campaign name, comments, lithology, and contacts.
- **Quickly edit**, **remove, add measurements** or **samples, and reorganize** the column order through a user-friendly and interactive spreadsheet.
- **Easily manage measurement campaigns**:
  - **Quickly add new measurement campaigns** (corresponding to different acquisition periods or different types of measurements) to the existing project.
  - **Identify the campaigns** by a color code and a specific name to trace the upload history.
  - **Filter out and select the campaigns** to be processed or visualized with a single click.
  - Rename, merge, suppress, and highlight campaigns.
- Export input/output database to CSV/Excel files.

### 2.5. Data validation

Process sequentially your data from acquisition to validation thanks to a multi-level database:

- **Acquisition Data**. Data acquired through a GPS connection and/or interactively by entering coordinates and measures. New data is checked before saving it, thus avoiding possible spoiling of the already existing database.
- **Raw Data**. Saved acquisition data, data from 2D real-time campaigns, or data (2D or 3D) imported from CSV or Excel files, possibly concatenated with data from previous campaigns.
- **Validated Data**. Data cleared from possible duplicates: too close data points are merged to avoid computation issues (choosing the average, the maximum, or the most recent value from the duplicates). Data below the detection limit are also automatically processed (assigning them either 0, the detection limit, or half this limit). Check the lithology/contacts consistency. The overlaps or duplicates of borehole samples are automatically detected.

## 3. SAMPLING DESIGN

- Prepare your sampling plan and automatically store target sample positions in the database.
- Set a **pre-defined sampling design** based on regular square, triangular or circular meshes or a random sampling design that provides a given number of samples.
- Via your systematic sampling, compute the **probability of hitting a hot spot** depending on the measurement support size and the target size.
- Thanks to statistical sampling designs, define your **optimal number of samples** (Sign test, Wilcoxon signed-rank test, Wilks formula).
- **Locate additional samples** by defining an optimization criterion and some points.

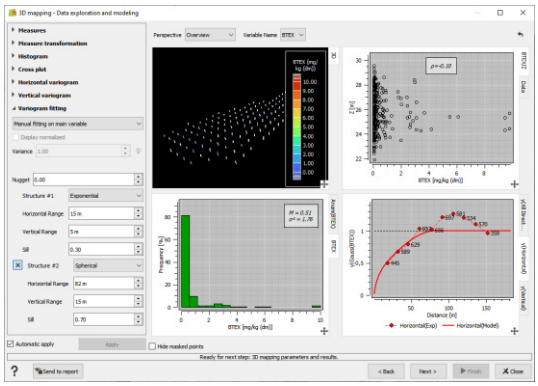
## 4. GEOSTATISTICAL PROCESSING

- Benefit from a simplified and robust technology based on Geovariances' 35 years' experience in geostatistical software development.
- All the needed tools to perform data analysis and contamination characterization are merged into a single geostatistical workflow.

### 4.1. Data analysis

- Calculate **statistics for each borehole**. Output figures are displayed in the 2D map view.
- Get instantaneous statistics on the contamination level, displayed in 4 views:
  - **Basemap**: to locate the sample points.
  - **Histogram** with standard statistics: minimum, maximum, mean, and standard deviation values. Assess the global data distribution.
  - **Univariate or multivariate experimental variogram, variogram cloud** and **variogram model**. Characterize the spatial variability of the contamination and highlight outlier samples.

- **Cross-plot / Boxplot with an auxiliary variable** for multivariate data analysis, considering the correlation between pollutants to guarantee estimation consistency. Also used to identify different data populations.



- Refine all calculated functions by tuning the involved parameters and axes interactively.
- Benefit from the **dynamic link** between these 4 representations and thoroughly explore your data. When you highlight points (by sample or digitalizing a polygon around the samples) in the base map or histogram bars, they are immediately highlighted in the other representations so you can check their locations. You may also ignore some samples (erroneous or outlier samples for instance) and instantaneously check the impact on the variogram and other maps.
- Achieve **data declustering** to correct possible spatial sampling bias (due to data clusters).
- Transform input data with a simple click:
  - Use a **log transformation**.
  - Use a **normal score transformation** to handle dissymmetric distributions and improve the structure identification while reducing the data variability (mandatory for risk assessment).
- Analyze **borehole sample lengths** and achieve **length regularization** to improve estimation quality and avoid bias (support effect taken into account).
- **Flatten data** before processing according to a reference surface, e.g., a lithological surface or the topography. This option allows the comparison of boreholes samples that are at the same depth relative to this surface.

## 4.2. Variography

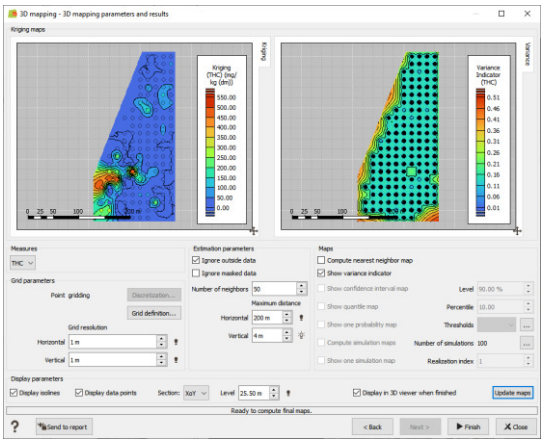
- Experience Kartotrak **automatic variogram fitting** and instantaneously get a model well-suited to your data.
- **Interactively fit your variogram model** and tune the involved parameters (structure type - spherical, exponential, or cubic - and range and sill for each structure).

  Or fit the variogram visually using the mouse and the anchors displayed on the variograms.

  You may add a second spatial structure in the model if the contamination shows different behaviors at different scales. Choose whether or not to add a nugget effect.
- Characterize the spatial behavior of your 3D boreholes through a dedicated **variogram analysis**.
- Identify and handle **anisotropies** using horizontal and vertical variograms.
- Handle the spatial variability of your **multivariate model** to ensure better estimation coherence with any other pollutant that could be associated with the same episode of pollution.

## 4.3. Estimation

- **Ordinary (co-)kriging** algorithm is implemented.
- A **moving neighborhood** is used by default in the kriging process to optimize computing time. You may tune the size of the search ellipsoid and the number of samples to get more robust results.

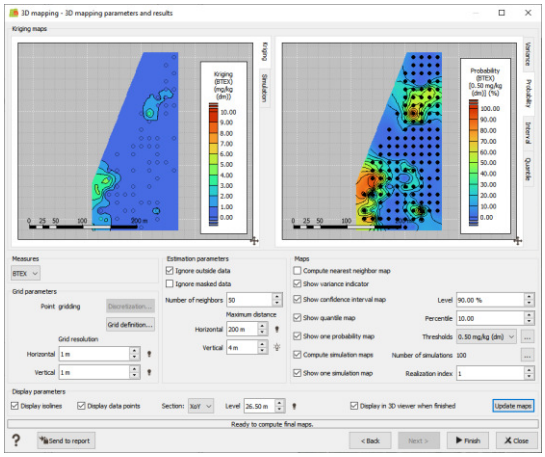


- **Maps are calculated on a** grid with a default mesh. You may adjust the mesh size to your needs (e.g., for consistency with the excavation mesh).

- Choose to compute a **punctual estimation** or estimate an average value of your contamination on a **block** (related to remediation support size).
- Mapping by nearest neighbor interpolation is also available.
- Storage of all parameters defined for the estimation to perfect traceability.

## 5. ESTIMATION AND RISK ASSESSMENT MAPS

- Make use of Kartotrak-proven algorithms and produce maps that help you identify hot spots, locate the areas to clean up, control costs, reduce uncertainty, optimize sampling locations, etc.:
  - Produce **contamination maps** using Ordinary (co-)Kriging and confidently estimate the contamination level all over the site.
  - **Assess the precision of the maps** through a variance indicator (calculated from the (co-) kriging standard deviation). It helps you in identifying poorly sampled areas that would require additional sampling.
- Make **data and risk-informed decisions**: Kartotrak allows **accurate uncertainty analysis** using a robust technique based on gaussian data transformation. The following maps are produced:
  - **Local probability of exceeding a given threshold**: to estimate the land surface with a given probability of exceeding a contamination threshold that you specify.




  - **Local quantile according to a given frequency**: to quickly compare remediation scenarios with optimistic (defining high quantiles) or pessimistic hypotheses (defining low quantiles).
  - **Local confidence interval width**: to identify areas showing a strong variability (vicinity of hot spots, transition areas between low and high contamination levels, etc.).

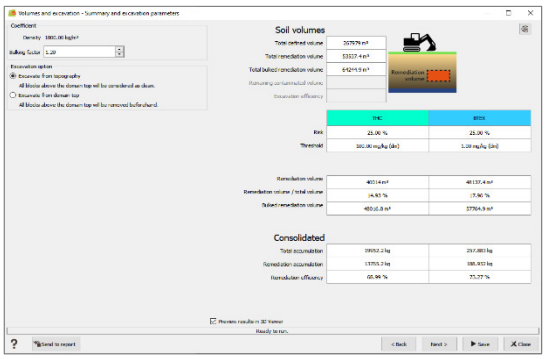
## 6. QUANTIFICATION OF REMEDIATION AREAS OR VOLUMES AND PRODUCTION OF EXCAVATION PLANS

- Benefit from a **comprehensive and innovative workflow** for quantifying the soil areas (in 2D) or volumes (in 3D) to remediate and related pollutant or contaminant masses considering one or several remediation thresholds and the risk of leaving contamination in place.

  The computations are based on geostatistical (co-)simulations and the derived probabilities. The contaminated areas, volumes, and masses to treat are expressed as risk curves reproducing the uncertainty associated with the contamination's variability.

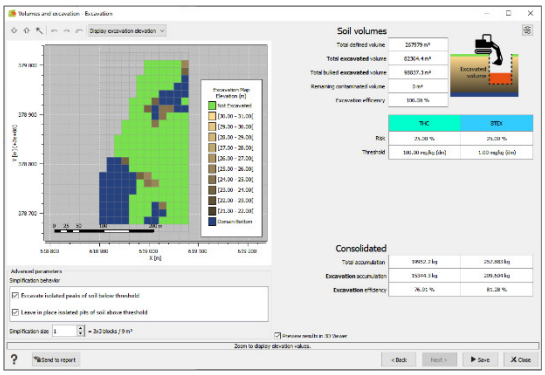
  Masses are derived from the volumes by applying a density coefficient.

  Several options are available:
  - **Single waste route**: when you wish to quantify the masses and areas or volumes of soil to be treated, considering one remediation threshold that you specify.
  - **Waste management plan**: when you want to optimize remediation according to several thresholds and waste treatment routes.
  - **Efficiency-driven (Pareto approach)**: when you want to optimize remediation efficiency, that is, maximize pollutant masses to be treated while minimizing areas or volumes.
- Quickly **evaluate and compare the efficiency of several remediation scenarios**. The efficiency is the ratio between the pollutant mass given thresholds and risks of leaving contamination in place and the total contaminated mass.



- **Benefit from multi-pollutant/multi-contaminant and multi-layer approaches** for optimal remediation.
- Derive the **excavation depth** for each defined mesh, that is, determine the deepest grid cell with contamination above thresholds.

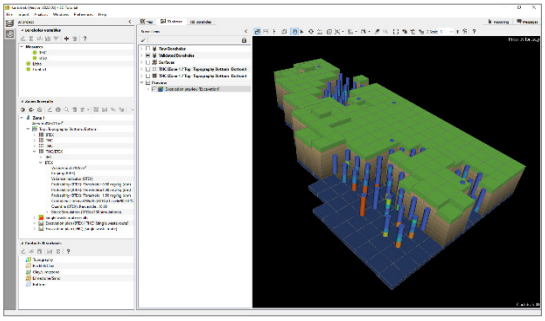
  **Excavation plans** are computed considering one or several pollutants and associated thresholds.



  **Adapt the excavation plan to remediation constraints** by modifying the excavation depth locally using **interactive tools** (dilation/erosion, dig, fill).

  Be informed on the **remediation efficiency**, i.e., the difference between the excavated soil mass and the remaining contaminated soil.

- **Visualize** the corresponding excavation map **in 3D**.



- Get the **decontamination efficiency** (excavated volume as a function of the contaminated volume). Consider or not **bulking factors** when calculating the volumes.

## 7. SITE COMPLIANCE CONTROL

- Check the **compliance** of your site with **regulatory thresholds** after remediation is completed thanks to the methods from the American guide **MARSSIM** (Multi-Agency Radiation Survey and Site Investigation Manual).
  - Assess data quality by checking the number of sampling points and verifying the assumptions of the statistical tests.
  - Apply **statistical tests** and conclude your data.

## 8. REPORTING & EXPORT

- Enjoy the efficiency of an **integrated word processor** and create your report as the project is built.

  Kartotrak offers all the essential tools to create your report as the project is built: copy/paste from the data tables, message windows, send the view from GIS and 3D Viewer as well as the associated color scales to the word processor, text edition and formatting, storage to pdf or odf documents, etc.

- **Export your results** (estimation or excavation plan) with all the georeferencing information as raster images (geoTIFF format) or raster data (GeoTIFF, ArcGIS, or NetCDF file) or in csv/Excel files.
- Strengthens your understanding of the contamination thanks to the **integrated 3D Viewer**:
  - In a single view, gather environmental information, 3D objects (such as buildings, tanks, underground networks via external files dxf, dwg, stl, wrl), boreholes, samples points, topography, or lithologic surfaces, and 3D computed maps.
  - Visualize the whole project, boreholes logs, and concerned volumes in 3D.
  - Analyze your 3D objects and estimation models using slicing, clipping, zooming, filtering tools, and database queries.

## 9. PROJECT MANAGEMENT

- Switch your project list from **icon to list view** and display general information regarding a project (e.g., location on disk, size, version).
- **Attach/detach** a project from your list of projects. **Backup/restore** a project for future use.
- Access the most recent projects and tutorials with a mouse click.
- Modify the coordinate system of a project.

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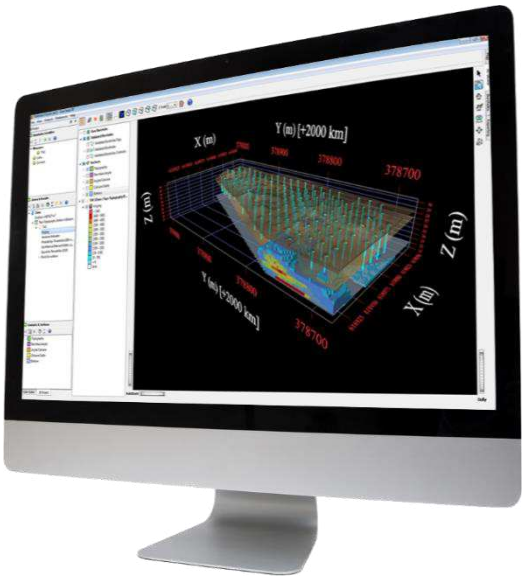
# kartotrak

## CONTROLLED MANAGEMENT OF CONTAMINATED SITES

### REDUCE RISK OF DELAYS AND OVERRUNNING COSTS DURING REMEDIATION WORK

**With Kartotrak, an integrated software solution for contaminated site and soil characterization:**

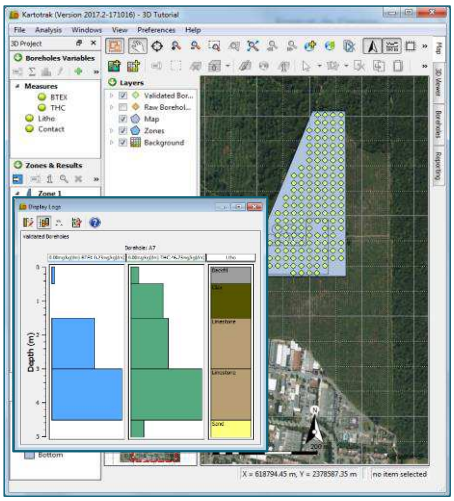
- Justify your decisions
- Adopt the industry's best practice
- Control your budget
- Become more efficient



RESPONSIBLE FOR STUDIES, PRECISELY DEFINE THE ZONES TO BE REMEDIATED

## Find out how Kartotrak facilitates data formatting and interpretation

### Compilation, quality control and visualization of contamination data



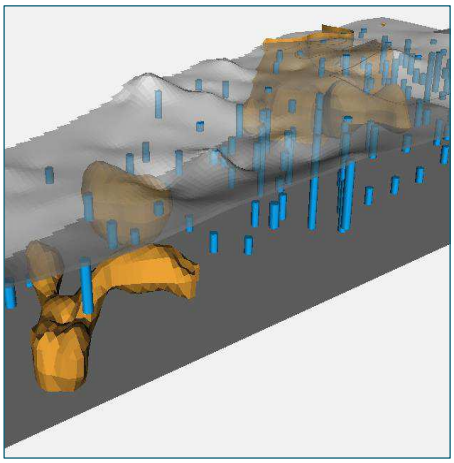
**Without Kartotrak**

You enter data in an Excel sheet and calculate statistics. Then, you import them in a mapping or GIS software package which enables you to illustrate and display contamination maps at different depth levels.

**With Kartotrak**

Load any type of data: borehole data, contamination typology and concentration, indirect pollution indices, topography, lithology, aerial views, building and buried structure locations... Display, control, validate data, compute statistics, visualize sampling plans in 2D or 3D, identify the contaminated volumes, calculate and visualize the volumes to be excavated in a few clicks. All this in a single software solution. And so, becoming more efficient.

### Thorough delimitation of contamination sources and concentrated contamination zones



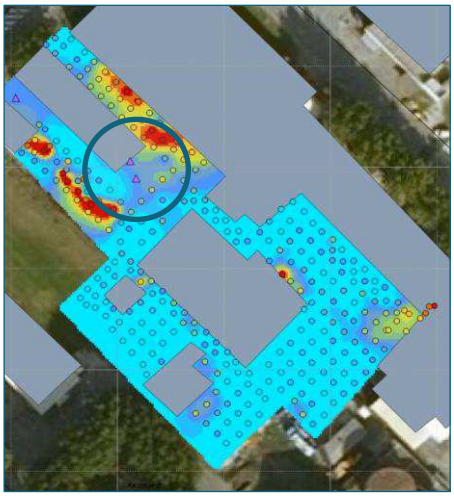
**Without Kartotrak**

You implement simple interpolations and empirical methods that can sometimes lead to biased estimates. You obtain maps that can be difficult to justify and that do not always allow you to know the initial state of the site.

**With Kartotrak**

Generate thorough maps which take into account the spatial behavior of the pollutants involved, and of which you know the level of accuracy. Delineate impacted zones with confidence. Calculate the soil surfaces and volumes requiring remediation. Compute the pollutant masses contained in these volumes while considering the cleanup levels to be met, plus the constraints related to remediation works and excavated soil management.

### Optimization of investigation density and location *



**Without Kartotrak**

To improve delineation of an identified contaminated zone after a first sampling campaign, you have to define a second campaign of investigation around this zone based on your budget.

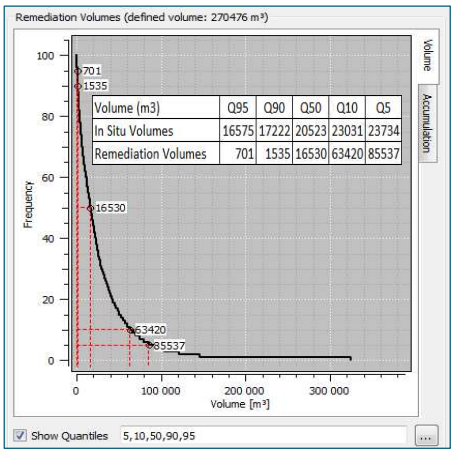
**With Kartotrak**

Size your new sampling campaign according to the intended remediation objective and the expected confidence level. Immediately identify zones with a significant level of pollution requiring additional characterization efforts. Locate the measurement points where the uncertainty or the variability of the contamination level is the most important. Improve your site evaluation at the as low as possible cost.

PROJECT MANAGER, JUSTIFY YOUR MANAGEMENT PLAN

## Find out how Kartotrak gives you the convincing arguments

### Control of the uncertainties in the zones and volumes which require remediation *




| Volume (m3) | Q95 | Q90 | Q50 | Q10 | Q5 |
|---|---|---|---|---|---|
| In Situ Volumes | 16575 | 17222 | 20523 | 23031 | 23734 |
| Remediation Volumes | 701 | 1535 | 16530 | 63420 | 85537 |

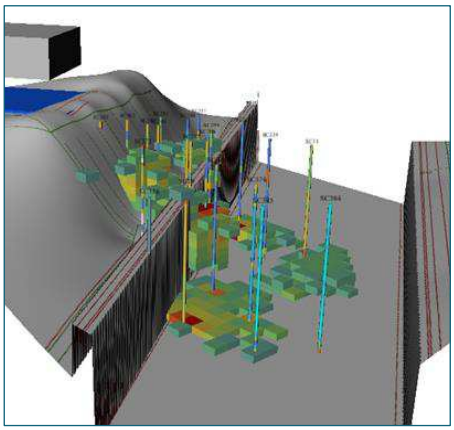
#### Without Kartotrak

You calculate a volume and establish a remediation budget without mastering levels of uncertainty, and usually in a subjective or even random way.

#### With Kartotrak

Calculate reliable models that depend on all the available data and an opposable scientific approach. Quantify the level of uncertainty of the estimated volumes and assess the error associated with a remediation scenario. Be confident with the remediation solutions you recommend and the estimated budgets. Provide your clients with a real decision-making tool that gives them full control over their projects thanks to a precise and scientific risk assessment.

### Facilitated communication with your clients and control authorities



#### Without Kartotrak

You provide tables of figures, graphs and plans, which are sometimes difficult to understand.

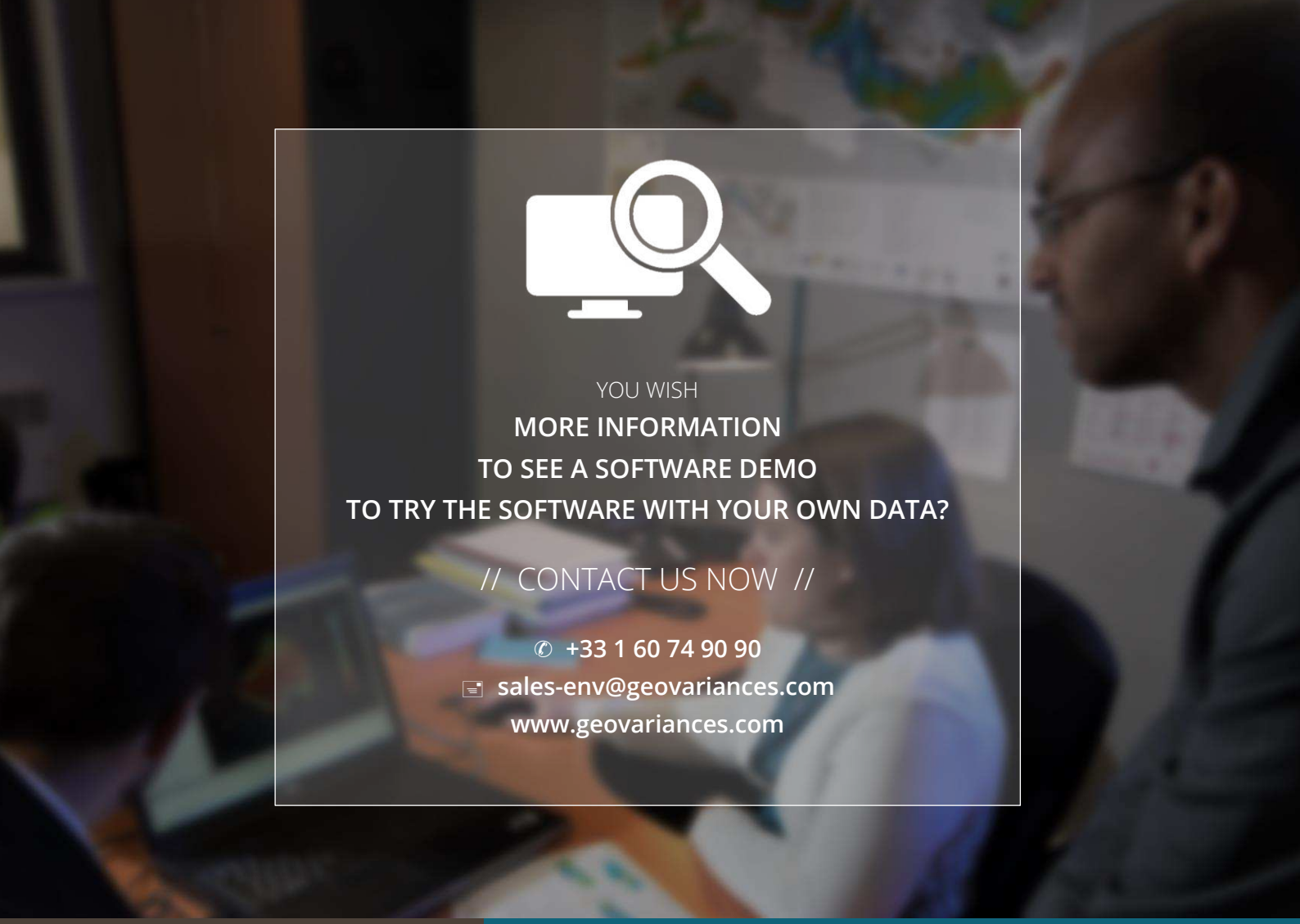
#### With Kartotrak

Create your own contamination assessment reports that you edit and modify at your convenience without leaving the software package. Communicate clear, concise and didactical results to your clients. Provide them with 2D or 3D maps which, at a glance, give them a better understanding of the site status and distribution and transfer of pollutants. Therefore, visualizing remediation works.

## BASED ON THE LATEST RECOMMENDATIONS, BENEFIT FROM THE RECOGNIZED STATUS OF THESE METHODS AND EARN THE TRUST OF YOUR CLIENTS

With Kartotrak, implement the methods recommended by national and international bodies:

- Méthodologie Nationale de Gestion des Sites et Sols Pollués | Ministère de la Transition Ecologique et Solidaire – MTES 2017
- Norme NF X31-620 : Qualité du sol. Prestations de services relatives aux sites et sols pollués. Exigences dans le domaine des prestations d'études, d'assistance et de contrôle | AFNOR - 2016
- Guide sur la Pollution Concentrée : définition, outils de caractérisation et intégration dans la Méthodologie nationale de gestion des sites et sols pollués | UPDS – 2016
- Définir une stratégie de dépollution : Approche basée sur la masse de polluant et la capacité de relargage d'une pollution | Rapport BRGM – 2016
- Guide de l'ASN n°24 : Gestion des sols pollués par les activités d'une installation nucléaire de base
- Norme ISO 18557 sur les Principes de caractérisation des sols, bâtiments et infrastructures contaminés par des radionucléides, à des fins de réhabilitation | ISO – 2017
- Guidance for Using Geostatistics in Developing a Site Final Status Survey Program for Plant Decommissioning | EPRI – 2016
- IAEA Analytical Quality in Nuclear Applications Series No. 49 - In Situ Analytical Characterization of Contaminated Sites Using Nuclear Spectrometry Techniques - Review of Methodologies and Measurements
- Tecdoc IAEA N°1017 - Characterization of radioactively contaminated sites for remediation purposes | 1998
- Tecdoc IAEA N°1251 - Design criteria for a worldwide directory of radioactively contaminated sites (DRCS) | 2001



YOU WISH

**MORE INFORMATION**

**TO SEE A SOFTWARE DEMO**

**TO TRY THE SOFTWARE WITH YOUR OWN DATA?**

## // CONTACT US NOW //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**sales-env@geovariances.com**

**www.geovariances.com**


* Kartotrak is available in 2 packs:

- **Kartotrak.one** for data analysis, site status mapping and excavation plan calculation.
- **Kartotrak.premium** which also enables sampling optimization, calculation of contaminated volumes and masses and risk analysis.

> Kartotrak is easy to learn and use. It lets you quickly achieve contamination data analysis and generate graphic visuals with professional rendering. Tauw France uses Kartotrak to improve their understanding of how a contaminated site works, to delineate in 2D or 3D a concentrated pollution, as well as to select and size management solutions (mass balance, cost-benefit balance, excavation maps, etc.)

**Sébastien Kaskassian**
**Project Manager and Head of Innovation – Tauw France**

## // WHY GEOVARIANCES //

**30+ years**
of experience in geostatistics-based software development

**500+ projects**
applying geostatistics for contaminated site management

**Global offer**
software package, training, consulting, mentoring, technical support

**Expertise recognized**
by the French Ministry of Environment, OECD, AIEA, CETAMA, EPRI, NICOLE

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Where no one has gone before

# kartotrak VS kartotrak.one

| FEATURES | .ONE | FULL |
|---|---|---|
| **Software Type** | | |
| Integrated workflow for contaminated site characterization | ✓ | ✓ |
| Embeds the functionalities required to analyze and visualize soil data even with a limited number of data | ✓ | ✓ |
| **GIS-Based Interface** | | |
| Loading standard geo-referenced vector file formats (Dxf, Mapinfo, Shapefile) | ✓ | ✓ |
| Import of raster files (GeoTiff, scanned paper maps, Google maps screen shots) | ✓ | ✓ |
| Interactive / Manual Georeferencing | ✓ | ✓ |
| Display customization (symbol shape, color, size, color scales, variables filtering) | ✓ | ✓ |
| Visualization of the whole project (data, results, lithological surfaces) both in a dedicated 3D Viewer and in the 2D map window | ✓ | ✓ |
| **Data handling** | | |
| Integration and handling of both 2D samples and 3D boreholes | ✓ | ✓ |
| Display of boreholes logs | ✓ | ✓ |
| Quick Excel exports (copy/paste) | ✓ | ✓ |
| Management of geographic projections (GDAL/OGR library) | ✓ | ✓ |
| User friendly interpolation of geological layers and underground water table | ✓ | ✓ |
| Campaign history | ✓ | ✓ |
| Multi-level database (Acquisition, Raw and Validated) | ✓ | ✓ |
| Data validation (detection limits, duplicates) | ✓ | ✓ |
| Data Quality Control and interactive Exploratory Data Analysis | ✓ | ✓ |

| FEATURES | .ONE | FULL |
|---|---|---|
| **Statistics / Sampling plan** | | |
| Sampling design module:<br>– preliminary plan<br>– probability of hitting spots | | <br>✓<br>✓ |
| Definition of the optimal number of samples thanks to statistical sampling designs (Sign test, Wilcoxon signed-rank test, Wilks formula) | | ✓ |
| Site compliance control (MARSSIM) | | ✓ |
| **Geostatistical processing** | | |
| Data declustering | | ✓ |
| Analysis of the boreholes samples lengths and length regularization | | ✓ |
| Data flattening according to a reference surface (e.g. topography) | ✓ | ✓ |
| Normal score transformation to handle dissymmetric distribution and improve the structure identification | ✓ | ✓ |
| Variogram fitting:<br>– Automatic<br>– Interactive<br>– Multivariate<br>– Vertical anisotropy | <br>✓<br>✓<br><br>✓ | <br>✓<br>✓<br>✓<br>✓ |
| Estimation:<br>– Nearest neighbor interpolation<br>– Punctual kriging and variance indicator<br>– Block kriging and variance indicator<br>– Co-kriging | <br>✓<br>✓<br><br> | <br>✓<br>✓<br>✓<br>✓ |
| Risk assessment mapping (geostatistical (co-)simulations, quantiles, confidence interval, probability of exceeding thresholds) | | ✓ |
| Computation of remediation surfaces and volumes to be excavated | | ✓ |
| Simplified preparation of excavation process | ✓ | ✓ |
| Sampling optimization on geostatistical results(2D) | | ✓ |
| **Reporting & Export** | | |
| Integrated reporting processor, export to pdf and odf formats | ✓ | ✓ |
| Export results with georeferencing information (geoTIFF, for 2D only) and csv files | ✓ | ✓ |

# **GEOVARIANCES - KARTOTRAK** :

Consulting Firms Pricing terms in € without VAT and Taxes (valid in 2022)


| Name | Description |
|---|---|
| **1 - License Pack** | |
| Kartotrak Pack One | GIS, Sampling, Data Analysis, 2D&3D Mapping, Reporting |
| Kartotrak Pack Premium | GIS, Sampling, Data Analysis, 2D&3D Mapping, 2D&3D Risk Assessment, Reporting |
| Real-Time Option | Real Time Data Acquisition (GPS & Measuring Devices) |
| **2 - License Model*** | |
| One-time Payment License | Licence with additional maintenance services |
| **3 - License Type*** | |
| Single-user | License assigned to one individual user ; cannot be shared between several people. |
| Site | License installed on a server or a dongle valid for any users of a single site |
| **4 - Support & maintenance services** | |
| 12 months period renewable each year | Unlimited access to Geovariances' Technical Support in English by phone / e-mail<br>New releases (upgrades / updates) |

| One-time Payment License | License | Maintenance |
|---|---|---|
| Kartotrak Pack One Single-user License | 2 950 € | 590 € |
| Kartotrak Pack Premium Single-user License | 7 950 € | 1 590 € |
| Kartotrak Pack Premium Site License | 11 950 € | 2 390 € |
| Real-Time Option | 1 950 € | 390 € |

| Discounted Price for Pack of several licences | Number | Discount | License | Maintenance |
|---|---|---|---|---|
| Pack-1 Kartotrak Pack One Single-user License | 1 | | 2 950 € | 590 € |
| Pack-3 Kartotrak Pack One Single-user License | 3 | 25% | 6 650 € | 1 330 € |
| Pack-5 Kartotrak Pack One Single-user License | 5 | 35% | 9 590 € | 1 920 € |

*License Terms & Conditions available at https://www.geovariances.com/en/general-conditions/

Geovariances

Where no one has gone before

# PIONEERING GEOSTATISTICS

## AND MAKING IT ACCESSIBLE

# Company overview

# Who we are

Geovariances

**A global provider of geostatistics-based solutions**, market leader and reference

**A pionneer in geostatistics**
Technical partnership with the Center of Geostatistics

MINES PARIS | PSL

**A Vela company**

Vela SOFTWARE DATAMINE

FOUNDED IN
**1986**

**35+ years**
OF EXPERIENCE IN GEOSTATISTICS AND SOFTWARE DEVELOPMENT

**40+**
TECHNICAL EXPERTS CONSULTANTS AND SOFTWARE DEVELOPERS

# We are part of Vela Group

Geovariances

CONSTELLATION SOFTWARE INC.

An international provider of market-leading software and services to several industries. Among the top 10 valuable software brands.

Vela SOFTWARE

Vela Industries Group: Metals and Mining, Oil & Gas, Construction & Engineering ...

DATAMINE

acquire

SNOWDEN Optiro

flairbase

minemax

# Our vision

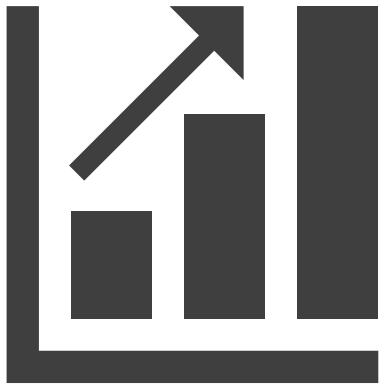
Geovariances

**To lead the geostatistics market**

by delivering **essential solutions** to our customers

# Our mission

Geovariances



We help our clients:

☑ **improve production and economic performance**

☑ **make better risk-informed decision**

by supporting them in integrating advanced geostatistics in their business process

# Our markets

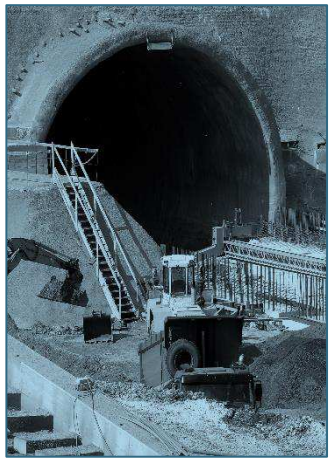
Geovariances

**Mining**

**Oil & Gas**

**Nuclear Decommissioning**

**Contaminated Sites**



**Geotechnical Engineering**

**Hydrogeology**
**Bioresources**
**Air Quality, etc.**

Our customers are private companies, consultancies, public bodies, ministers

**500+** CLIENT COMPANIES

# What we help our clients achieve

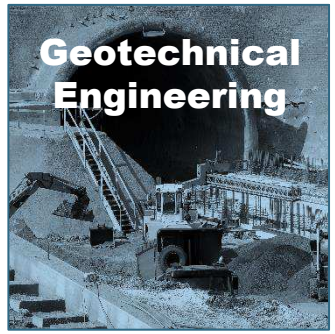
Geovariances


- Geological domain definition
- Resource estimation
- Resource classification
- Resource uncertainty characterization
- Drillhole spacing optimization


- Seismic filtering
- Time-to-depth conversion
- Reservoir characterization
- Uncertainty quantification and risk analysis
- Geobodies connectivity analysis



- Sampling campaign optimization
- Contamination mapping
- Delineation of impacted areas
- Quantification of masses and volumes of soil to be treated
- Classification of contaminated areas and wastes with a quantified risk analysis
- Optimization of waste treatment routes





- Property mapping (soil, water quality, air quality, etc.)
- Subsurface characterization
- Modeling of aquifer geometry
- Optimization of measurement networks
- Uncertainty quantification and risk analysis

# Recognized expert in geostatistics

Geovariances

We promote geostatistics through **international working groups** and are involved in **international methodological guides**

IAEA
International Atomic Energy Agency

OECD
BETTER POLICIES FOR BETTER LIVES

NICOLE
Network for Industrially Co-ordinated Sustainable Land Management in Europe

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
MINISTÈRE DE LA TRANSITION ÉCOLOGIQUE ET SOLIDAIRE

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

RECORD

CETAMA

afite
Le réseau d'experts pour l'environnement

avenia

AGAP QUALITÉ GÉOPHYSIQUE APPLIQUÉE

# Our offer, global and flexible

Geovariances

## Ready-to-use software solutions

## Training courses

Comprehensive training program in geostatistics and software use

## Custom software development

Libraries, Python-based routines

## Consulting and mentoring services

Mapping, modeling, resource estimation, risk analysis

Workflow setup and integration in global company processes

# Our software solutions

# Ready-to-use software

Geovariances

Our solutions deliver **exceptional reliability and scientific rigor**

isatis.neo

**COMPREHENSIVE AND ADVANCED GEOSTATISTICS SOLUTION**

Standard, Mining, Petroleum

kartotrak

**DEDICATED TO CHEMICAL AND RADIOLOGICAL CONTAMINATION CHARACTERIZATION**

For remediation optimization

**1500+** LICENSES WORLWIDE

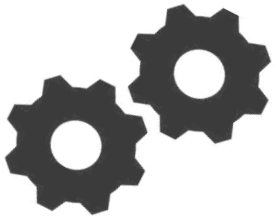
# Customizable software

Geovariances

We target your specific needs with **tailor-made developments**
for more efficiency and greater interoperability with your other solutions

## WORKFLOW AUTOMATION

Development of automated routines through batch scripting



## GEOSTATISTICAL LIBRARIES

ISAPI — HALLIBURTON Landmark

POLAPI — DATAMINE

HQMETEO — Hydro Québec

QUICKMAP — NUVIA

# Customizable software

Geovariances

Isatis.neo is a highly customizable solution.

**We adapt and integrate it into the core of your processes**


**THE VERY GEOSTATISTICAL ROUTINE YOU NEED**

**PERFECTLY CONNECTED TO YOUR GLOBAL PROCESS**

whatever the data format and the process complexity

# Customer-driven software

Geovariances

We are committed to deliver software solutions
that **fully meet your expectations**

**CUSTOMER-DRIVEN** INNOVATIONS
(USERS MEETINGS, BETA-TESTS)

OUR DEVELOPERS AND CONSULTANTS WORK TOGETHER TO DELIVER USABLE AND RELEVANT SOLUTIONS

FOCUS ON (1) **INTERFACE**, (2) **INTEROPERABILITY**, (3) **INNOVATION**, (4) **PYTHON SCRIPTING**

# Innovative software

Geovariances

We are committed to **further advancing geostatistics** with industrial partners

**2017-2021 | INSIDER**

*Improved nuclear site characterization for waste minimization*

Project about sampling strategy with 27 partners

**2018-2019 | SPDE**

A new engine for estimation and simulations offering a quantum leap in performance

**2015-2018 | uncerTZ**

Depth conversion and uncertainties

UNCERTZ

**2015-2018 | Horizon 2020**

*Real-time framework to decrease environmental impact and increase resource efficiency in mining operations*

Data integration

REAL TIME MINING

**2012-2015 | S2RM**

Simulation Scenario Reduction in Mining (in partnership with MINES ParisTech's Cerna)

**2010-2013 | G2DC**

Geostatistical and Geological Domaining

**2006-2009 | M2RC**

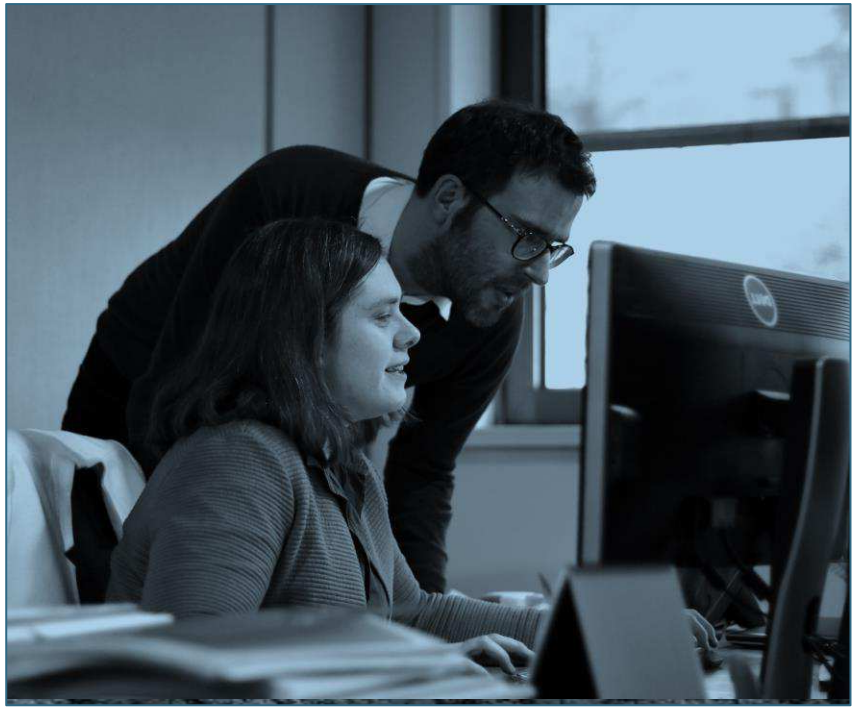
Multivariate Recoverable Resources

# Our customer services

# Technical support

Geovariances

We remain by your side to ensure
**you are getting the best** of our software products



**HELP DESK** | **UNLIMITED** ACCESS TO **PERSONALIZED** TECHNICAL SUPPORT PROVIDED BY **EXPERIENCED** STAFF

**MENTORING** | WE WORK TOGETHER ON YOUR DATA TO STREAMLINE YOUR PROCESS

**MAINTENANCE** | **FREE ACCESS TO 3** RELEASES A YEAR + CORRECTIVE VERSIONS

**TECHNICAL RESOURCES** | FREE ONLINE ACCESS

# Training

Geovariances

We support you in your learning journey and ensure that at the end of your training, **you are up and running**

A CATALOG OF **30+** COURSES

EN FR SP PT

**PROGRAMS ADAPTED TO YOUR SPECIFIC REQUIREMENTS AND SKILL LEVEL**:
FOR BEGINNERS | ADVANCED USERS | AWARENESS
STANDARD | CUSTOMIZED CONTENT
ON YOUR SITE| AT OUR OFFICES | ONLINE

# Consulting

Geovariances

Our consultants help you **unlock the situation** and save you time

A **FLEXIBLE** AND **REACTIVE** TEAM OF CONSULTANTS WITH **SIGNIFICANT EXPERIENCE** IN THEIR FIELDS

**BEST PRACTICE APPROACH** GAINED FROM MANY YEARS OF EXPERIENCE

**TRANSPARENT** AND **AUDITABLE** SERVICES FOUNDED ON OUR LATEST SOFTWARE TECHNOLOGY

# Some of our clients

# Mining

Geovariances

# Subsurface characterization

Geovariances

Oil & Gas

Geological surveys

Research institutes

Geotechnical engineering

Various

# Nuclear Decommissioning

Geovariances

# Contaminated Sites

Geovariances

Geovariances

Where no one has gone before

# THANK YOU

**www.geovariances.com**

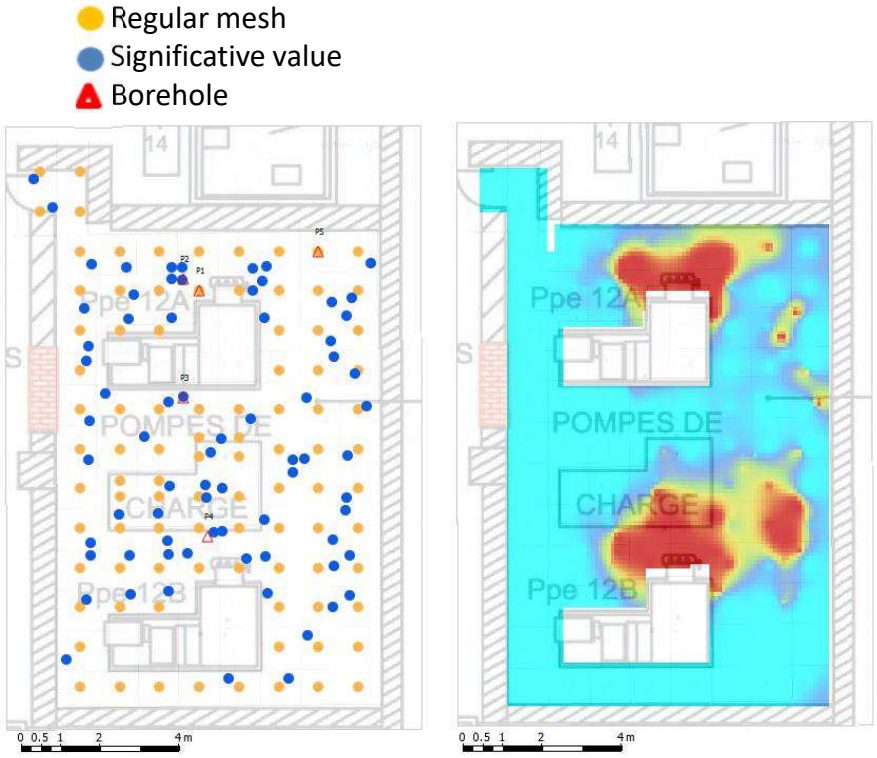
**info@geovariances.com**

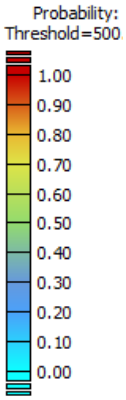
# RADIOLOGICAL CHARACTERIZATION OF BUILDINGS

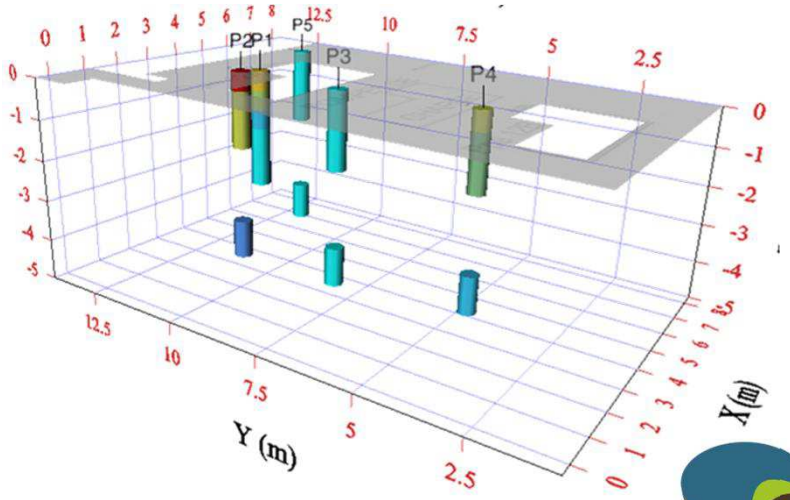
- ## Context & Objectives:
  - Dismantling and decommissioning of Chooz A, a EDF NPP in North-East part of France
  - Development of the characterization methodology (in situ vs. destructive) for contaminated concrete

- ## Methods:
  - 2D geostatistical workflow
  - Analysis of migration profiles

- ## Outcomes:
  - Comparison between measurements according to a 1m² regular grid and highest point in the same square
  - Sensitivity analysis to the mesh size
  - Better understanding of appropriate locations for drillholes due to historical knowledge and 2D radiation mapping



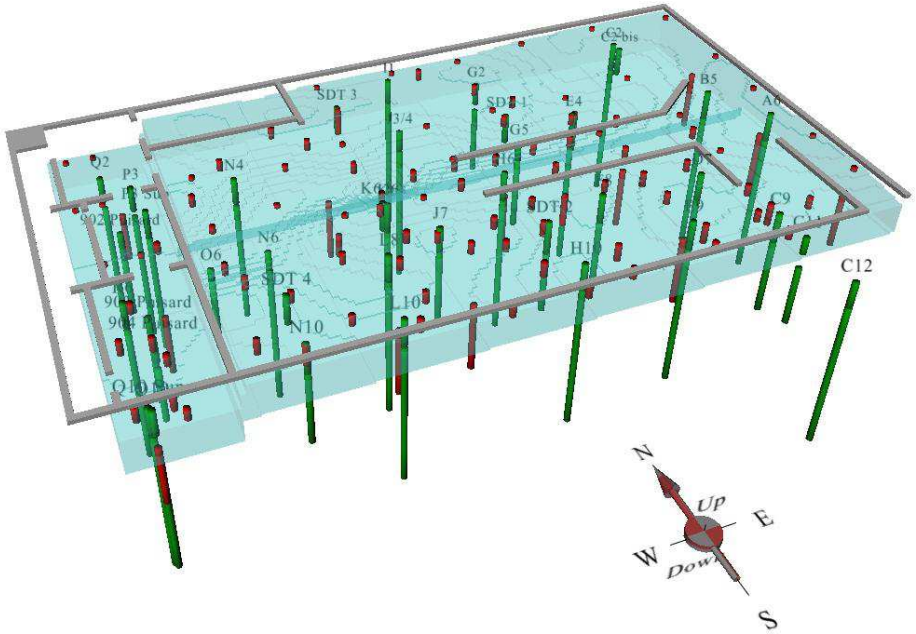




Date: 2015

Geovariances

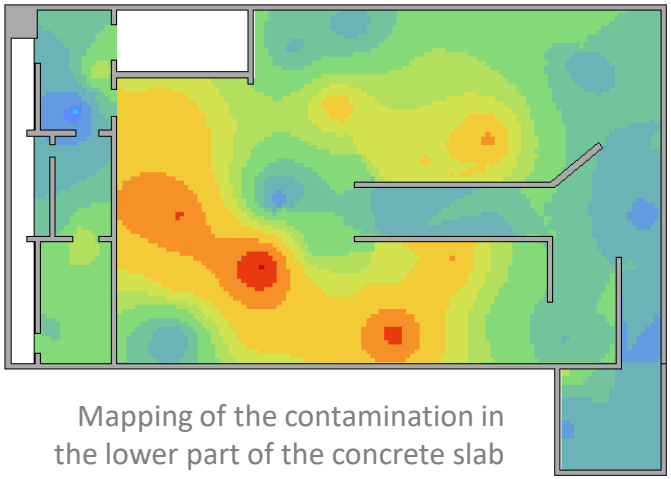
# RADIOLOGICAL CHARACTERIZATION OF BUILDINGS

- Context & Objectives:
  - Dismantling and decommissioning of the radioactive liquid treatment station of Brennilis NPP
  - Comparison of two drill hole campaigns for the estimation of contaminated materials




- Methods:
  - Classical statistics (correlation clouds…)
  - 2D and 3D geostatistical processing
  - Accumulation curves for total activity estimation

- Outcomes:
  - Heterogeneous sampling strategies not allowing a direct comparison but global results are similar (except for extreme values)
  - Good coherence with historical information
  - Evaluation objectives and data analysis to be determined before starting the investigations



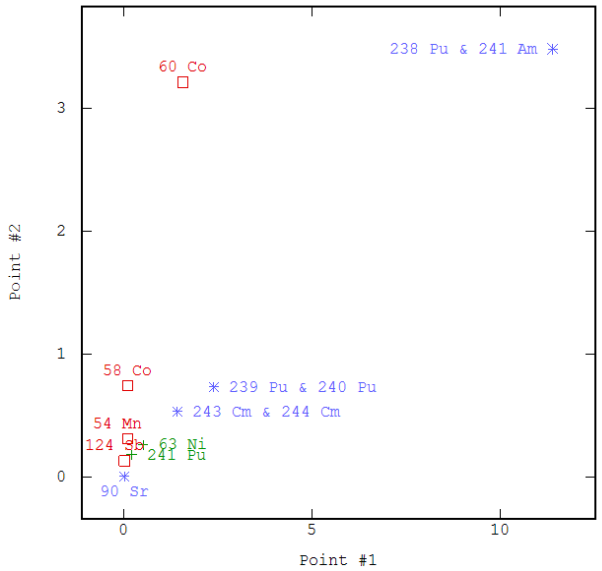
Mapping of the contamination in the lower part of the concrete slab

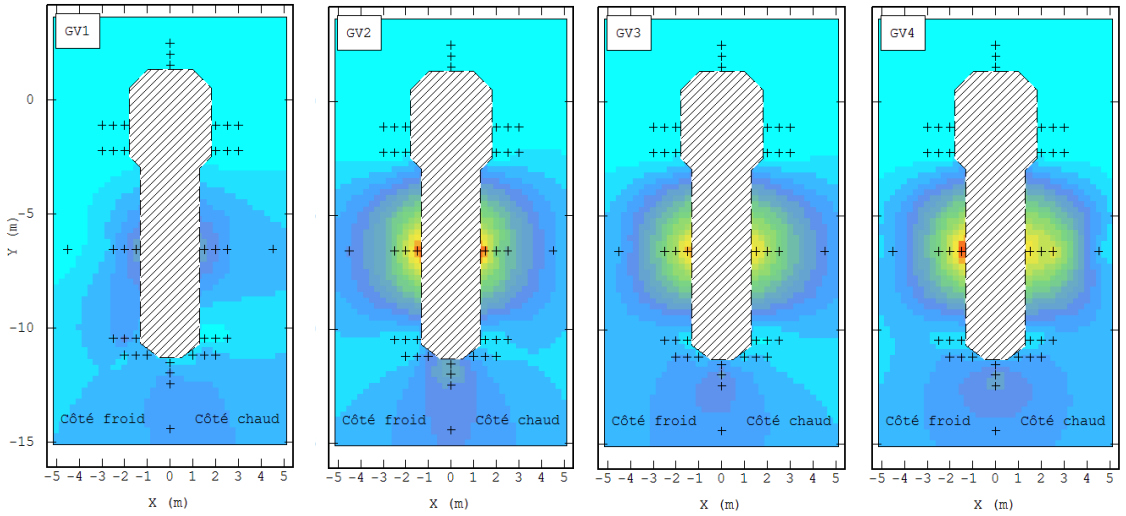
Date: 2009

Geovariances

# CHARACTERIZATION OF NUCLEAR COMPONENTS

- **Context & Objectives:**
  - Dismantling and decommissioning of Chooz A NPP
  - Analysis of a large dataset dating just before the reactor shutdown (1991) and more recent non destructive measurements (2007) around the steam generators
- **Methods:**
  - Classical statistics (correlation clouds, PCA…)
  - 2D geostatistical processing
- **Outcomes:**
  - Identification of distinct nuclide families (as for correlation and contamination behavior)
  - Identification of outliers (confirmed by historical facts)
  - Mapping the dose rate around the steam generators (decrease with distance, spatial repartition of the extreme values…)



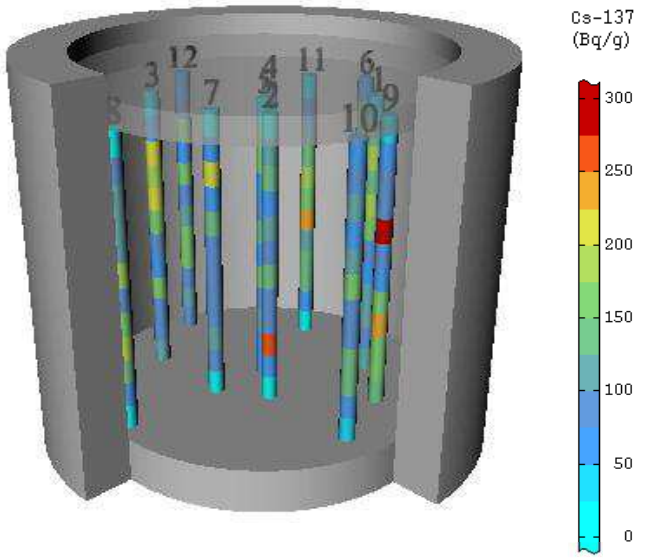



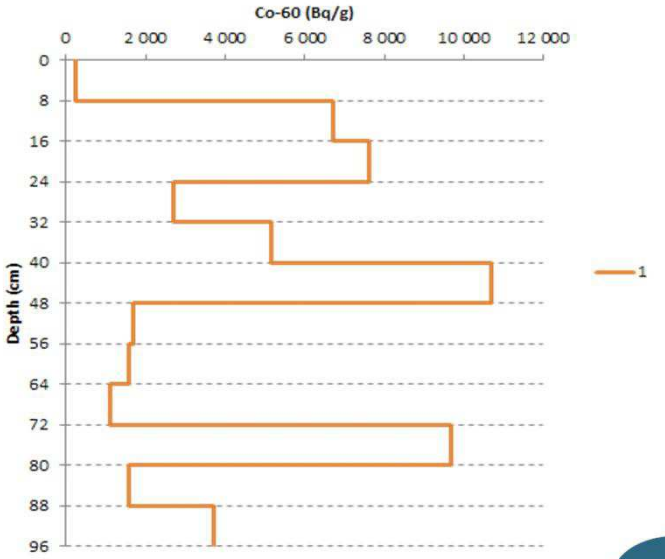

Date: 2011

Geovariances

# CONTROL OF CEMENTED HULLS

- **Context & Objectives:**
  - Assessment and improvement of producer Radwaste packages quality mastery, guarantee of the Radwaste disposal safety, maintain of the public confidence
  - Packages inspected: 2m$^3$ concrete hulls containing radioactive sludge or concentrate immobilized by a hydraulic binder (expected to be homogeneous)
- **Methods:**
  - Exploratory data analysis
  - Analysis of support effect
- **Outcomes:**
  - Identification of outliers (confirmed by production facts)
  - Identification of correlations between nuclides
  - Estimation of the homogeneity of the waste package
  - Optimization of the sampling strategy for next packages




Date: 2011-2013

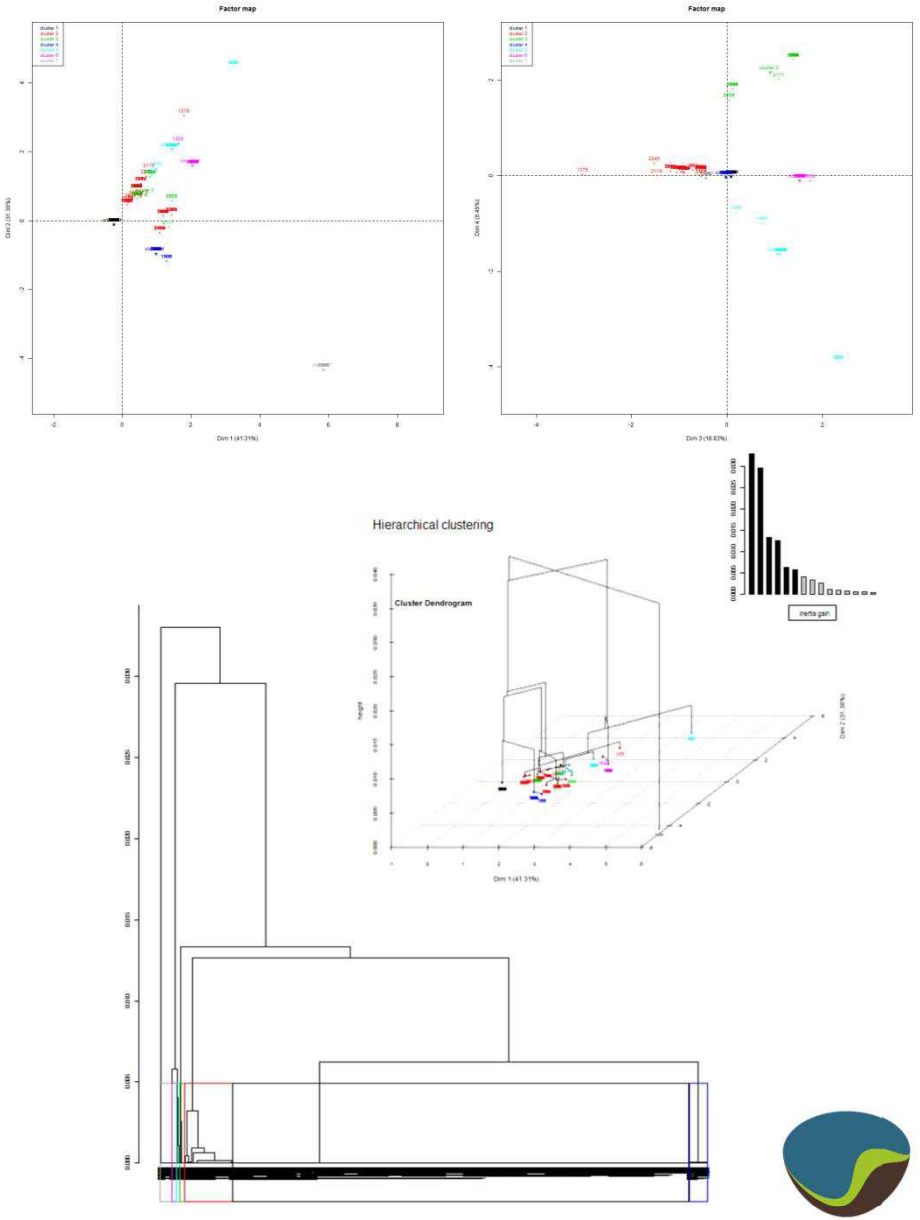
Further reading:

Pombet D., Desnoyers Y., Aggarwal S., Charters G. (2013) Destructive testing: dry drilling operations with TruPro® system to collect samples in a powder form, from two hulls containing immobilized waste in a hydraulic binder. In Proc. of ICEM 2013 congress, Brussels, Belgium.

Geovariances

# Statistical Classification of Legacy Hulls

- **Context & Objectives:**
  - Characterization of ≈ 2,000 old radioactive waste in cemented hulls, still stored on Saclay CEA center
  - Analysis of the existing database and identification of relevant waste groups for future agreements
- **Methods:**
  - Exploratory data analysis to consolidate and exploit the database : histograms, correlations…
  - Classification methodology : Sokal & Michener coefficient, correspondence analysis, hierarchical clustering
- **Outcomes:**
  - Sensitivity analysis to the classification method and the number of classes
  - Identification of distinct groups with specific elements and representative units
  - Recommendations about sampling strategy

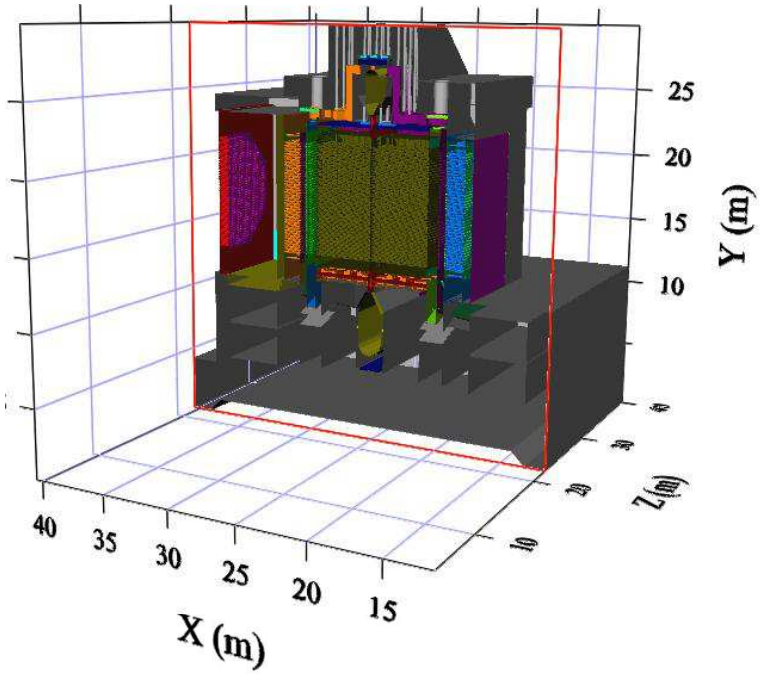



Date: 2014-2015

Geovariances

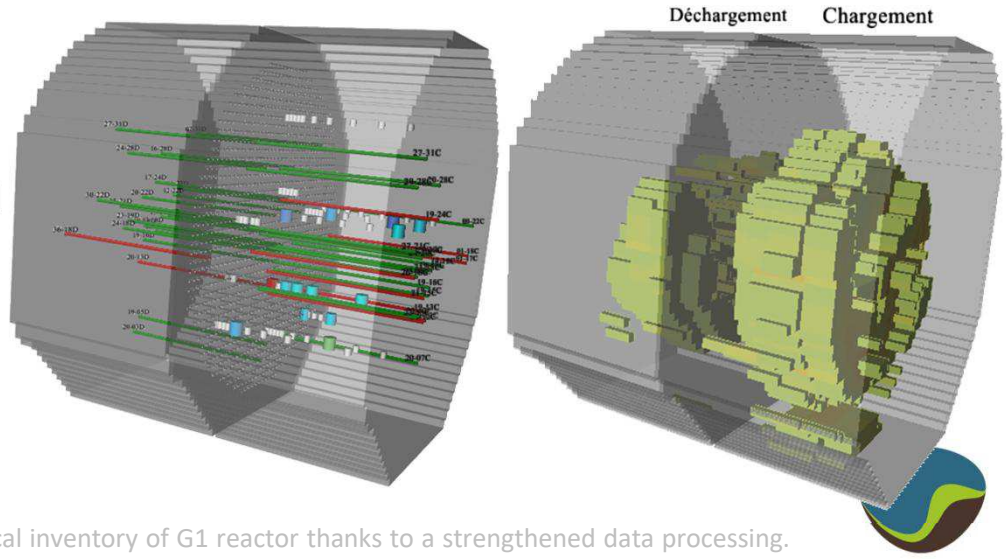
# CHARACTERIZATION OF AN EXPERIMENTAL REACTOR

- **Context & Objectives:**
  - Characterization of reactor G1 in Marcoule CEA center (graphite, metals and concrete)
  - Integration of geostatistical processing with historical data and numerical model (activation)
  - Optimisation of ongoing sampling campaigns (2015-2016)




- **Methods:**
  - Exploratory data analysis to consolidate the heterogeneous database : histograms, boxplots, PCA, linear regression, directional variography
  - Comparison of results from samples and outputs of the activation model

- **Outcomes:**
  - Data management and visualisation tool with physical model (SolidWorks), numerical model (MCNP) and (geo-) statistical processing
  - Update of the nuclide inventory for Andra
  - Identification of uncertain areas according to sampling density and specific nuclides



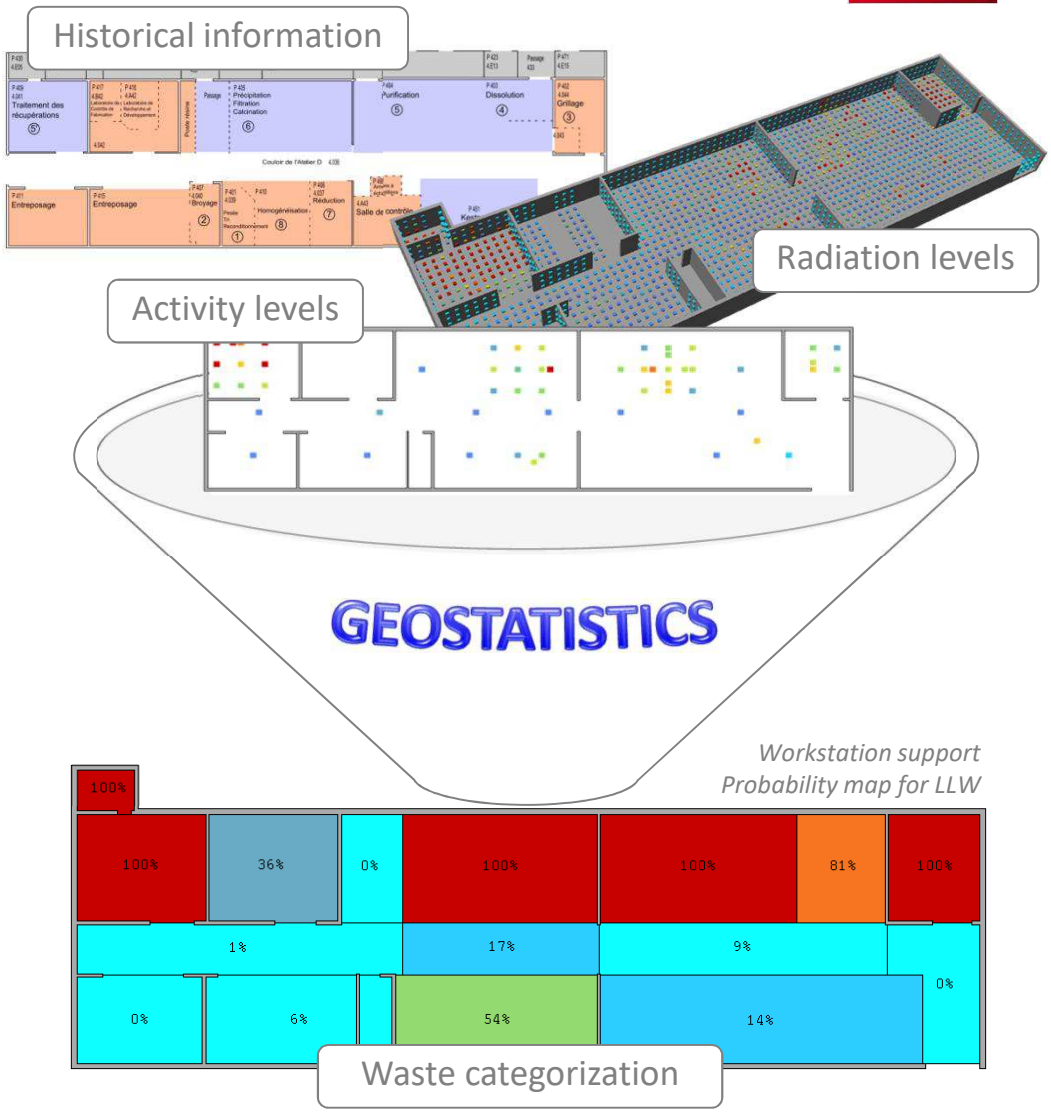

Date: Since 2013...

**Desnoyers Y.,** Da Costa M., Magnin M., Lerat V. (2017) Updated radiological inventory of G1 reactor thanks to a strengthened data processing. In *Proc. of Waste Management 2017* Conference, Phoenix, Arizona, USA.

Geovariances

# RADIOLOGICAL CHARACTERIZATION OF BUILDINGS

- **Context & Objectives:**
  - Dismantling and decommissioning of ATUE facility (Uranium Workshops)
  - Segregation and characterization of contaminated materials (mainly concrete structures)
- **Methods:**
  - Multivariate analysis
  - Non-linear estimations
- **Outcomes:**
  - Optimization and rationalization of the evaluation methodology
  - Providing essential decision-making tools for D&D projects saving time and money




Date: 2008-2010 (PhD Thesis)

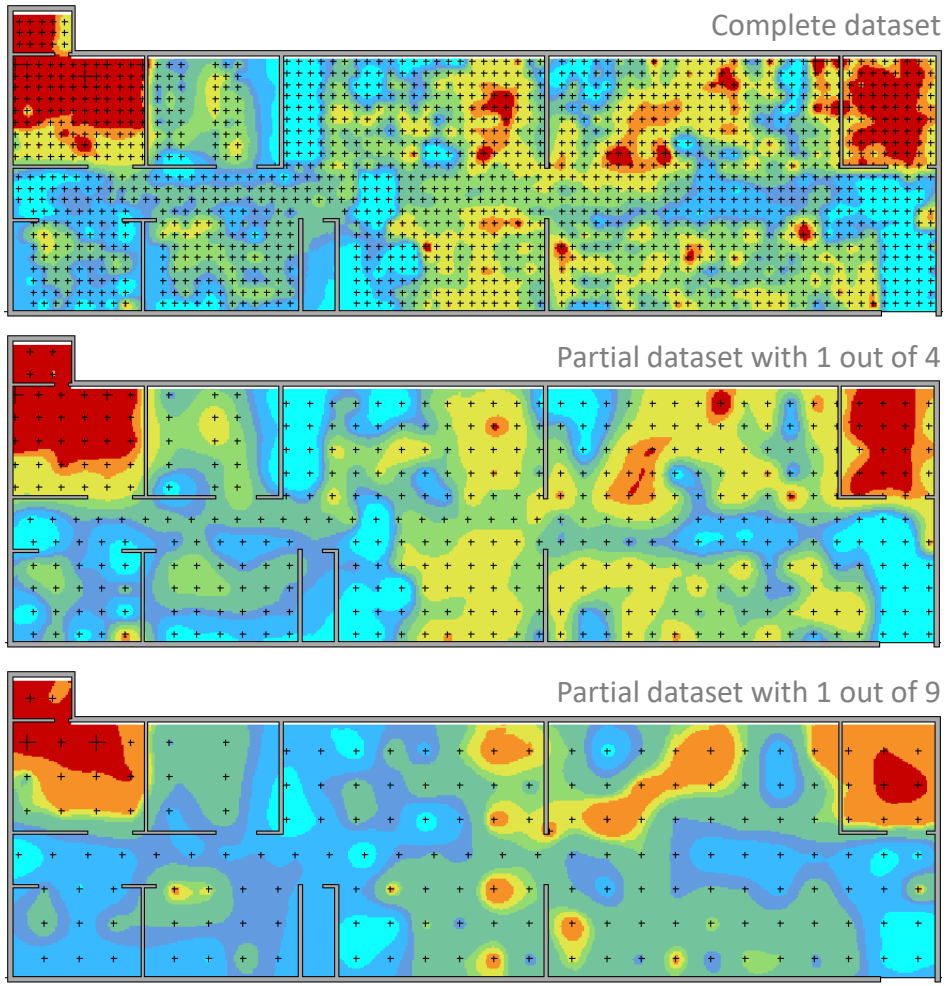
Further reading:

Desnoyers Y., Dubot D. (2011) Geostatistical Methodology For Waste Optimization Of Contaminated Premises, in Proc. of ICEM 2011 congress, Reims, France.

Geovariances

# RADIOLOGICAL CHARACTERIZATION OF BUILDINGS

- **Context & Objectives:**
  - Dismantling and decommissioning of ATUE facility (Uranium Workshops)
  - Optimization and rationalization of the sampling strategy
- **Methods:**
  - Variographic analysis
  - Non-linear and multivariate techniques
- **Outcomes:**
  - Systematic presence of spatial continuity for radiological contamination
  - Optimize the different sampling phases:
    - Determination of the initial mesh
    - Nearly real-time mapping to optimize iterative sampling strategies




Date: 2008-2010 (PhD Thesis)

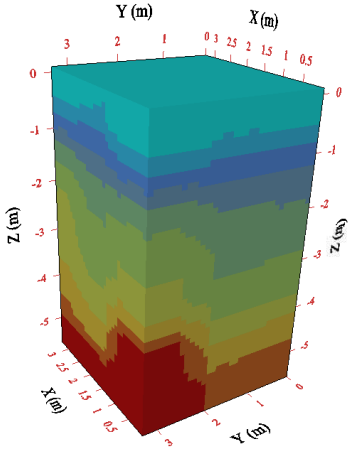
Further reading:

Desnoyers Y., J.P. Chilès, N. Jeannée, J.M. Idasiak, D. Dubot (2009) Geostatistical methods for radiological evaluation and risk analysis of contaminated premises, International Symposium "Nuclear energy" - Sien 2009, Bucharest.

Geovariances

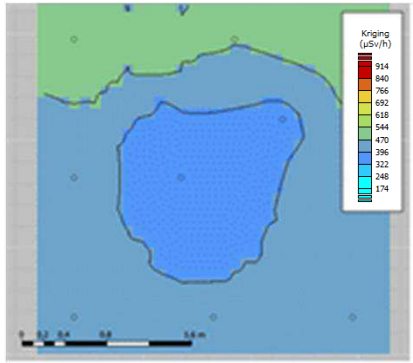
# DOSE RATE IN A TANK

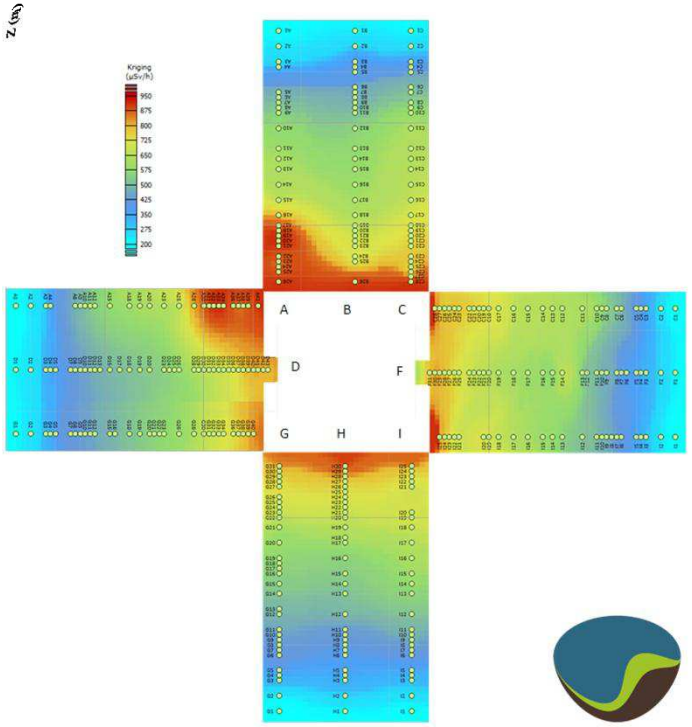
- **Context & Objectives:**
  - Dismantling and decommissioning of "hot water treatment" plant of Belgoprocess (built during the 60's)
  - Characterisation of 9 large storage tanks that represent the most important source of remaining contamination
    - Estimation of dose rates for ALARA-studies
    - Optimisation of destructive sampling




- **Methods:**
  - Exploratory data analysis and variographic analysis to consolidate the dataset
  - 3D geostatistical processing

- **Outcomes:**
  - 3D mapping of dose rate
  - Experience gained in characterization using indirect measurements
  - Optimization of sample number, order and location



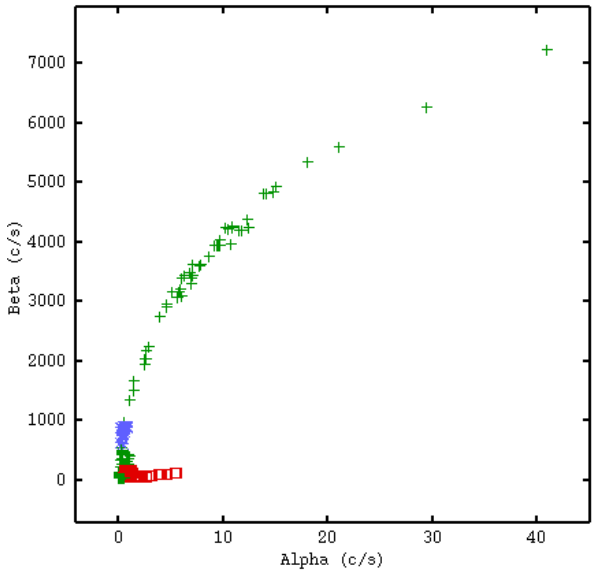

Date: 2015

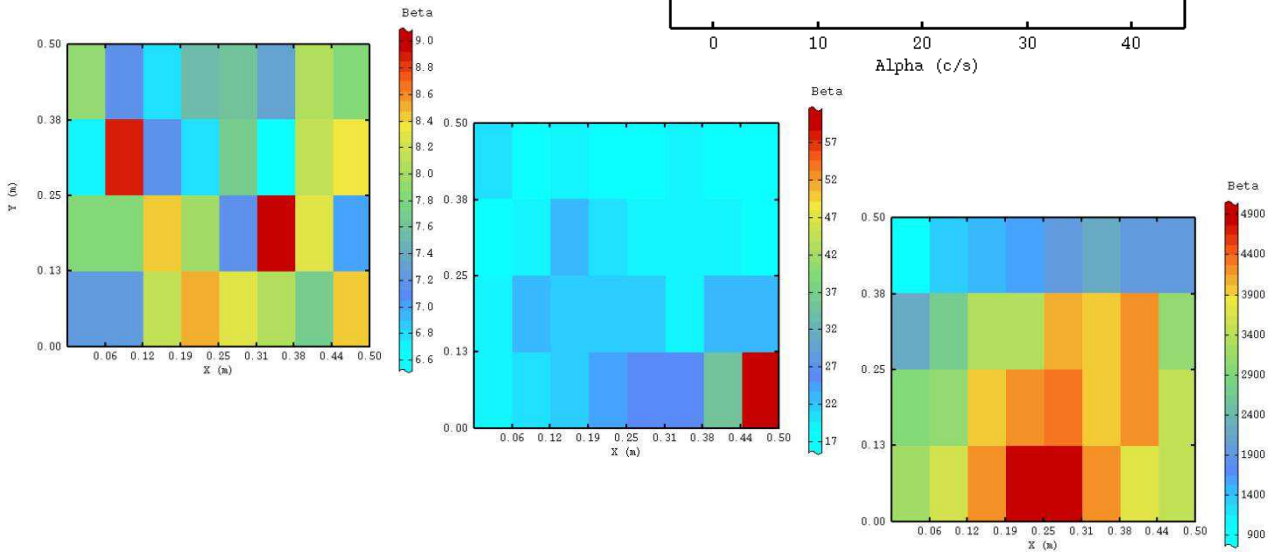
Geovariances

# CHARACTERISATION OF AN ACTIVE CULVERT

Studsvik

- **Context & Objectives:**
  - Parts of the active culvert have to be dismantled while others should stay in operation
  - Radiological survey of concrete structures as well as metal pipes (hundreds of meters)
- **Methods:**
  - Exploratory data analysis and variographic analysis
  - Synthetic example on a 1D (geostatistical simulation)
- **Outcomes:**
  - Identification of outliers
  - Classification in three main families at a 0.5 x 0.5 m
  - Recommendations and optimization of the sampling strategy for future characterization campaigns




Date: 2014

Further reading:

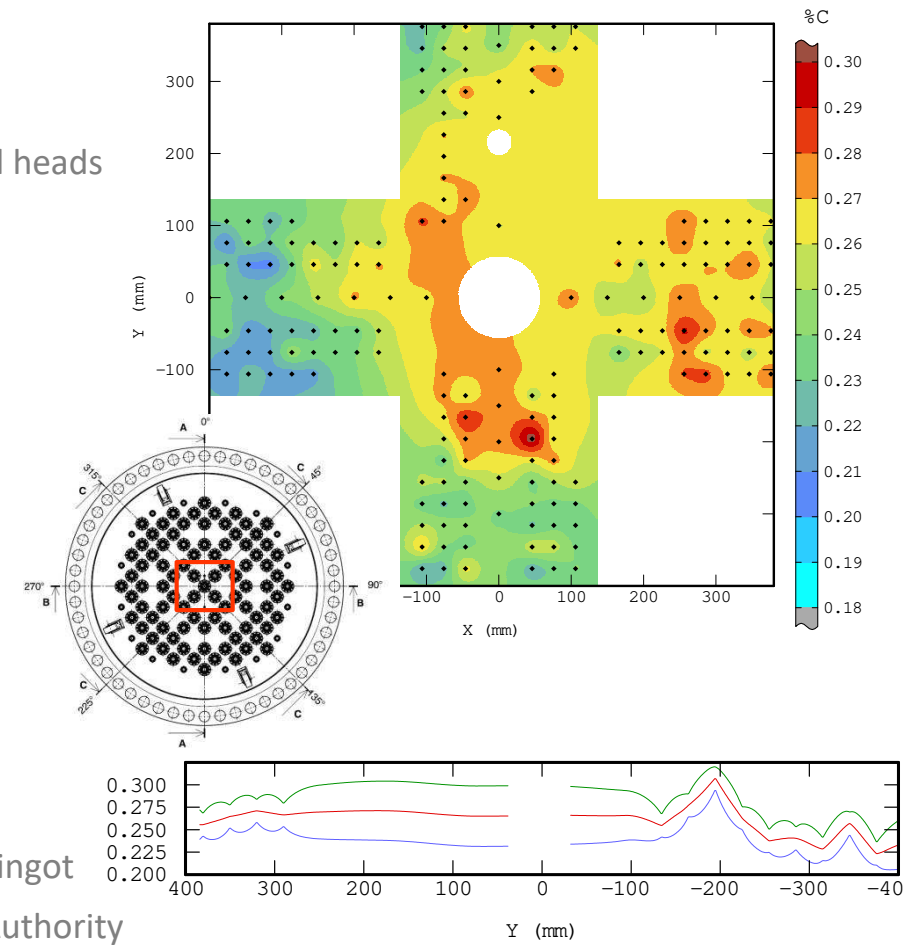
Lidar P., Larsson A., Desnoyers Y. (2014) Geostatistical characterisation of contaminated metals: methodology and illustrations. In Proc. of Symposium on Recycling of Metals arising from Operation and Decommissioning of Nuclear Facilities, Studsvik, Sweden.

Geovariances

# CARBON MAPPING OF REACTOR VESSEL HEADS

framatome

- **Context & Objectives:**
  - Physical properties of foundry pieces
  - Special focus on carbon segregation
  - Within an inter-comparison of several reactor vessel heads
- **Methods:**
  - Classical 2D geostatistical workflow
  - Kriging mapping and uncertainty quantification
- **Outcomes:**
  - Classification of 5 pieces according to their maximum content of carbon
  - Quantification of nugget effect thanks to individual measurements at the same location
  - Comparison of surface and section mapping
  - Critical review of the sampling strategy
  - Additional map of the carbon content at a full scale ingot
  - Part of the global instruction for the French Safety Authority approval of the Flamanville EPR (Decision n° 2018-DC-0643)




Date: 2016

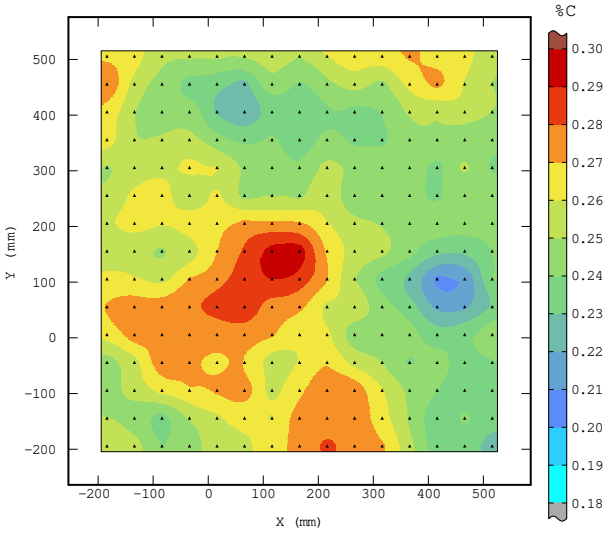
Desnoyers Y., Calonne O., Segond M., Binet H. (2018) Geostatistical carbon content mapping of EPR vessel heads using mobile spectrometer. In Proc. of Fontevraud 9 Conference, Avignon, France.

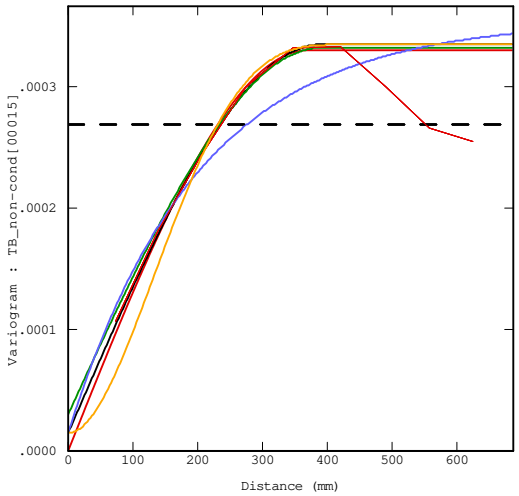
Geovariances

# MODELLING SENSITIVITY FOR CARBON MAPPING

framatome

- **Context & Objectives:**
  - Carbon mapping of reactor vessel heads
  - Quantification of estimation uncertainty
- **Methods:**
  - Classical 2D geostatistical workflow
  - Sensitivity tests and analysis of various estimation alternatives: uncertainty on variogram fitting, conditional expectation, kriging with external drift…
- **Outcomes:**
  - Quantification of nugget effect thanks to individual measurements at the same location
  - Comparison of the dispersion to a reference interpolation map
    - For average, unbiased differences
    - For standard deviation, most impacting factor is nugget effect (that can be capped thanks to the experimental data)
  - Relevance of an appropriate sampling mesh to contain uncertainties



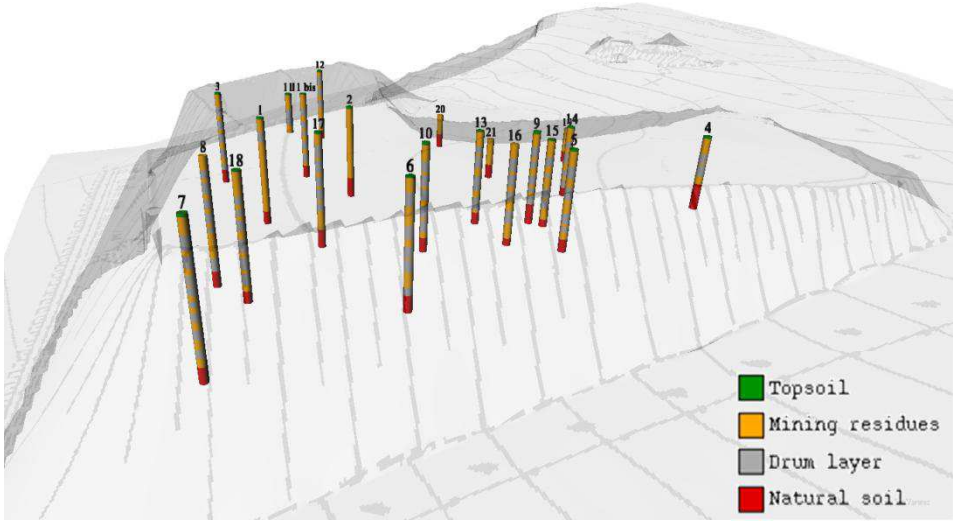

| Modelling variation | Standard-deviation (%C) |
|---|---|
| Variogram model | $2.10^{-3}$ to $4.10^{-4}$ |
| External drift | $8{,}4.10^{-4}$ |
| Conditional expectation | $9{,}0.10^{-4}$ |
| Anisotropy | $7{,}8.10^{-5}$ |

Date: 2016

Geovariances

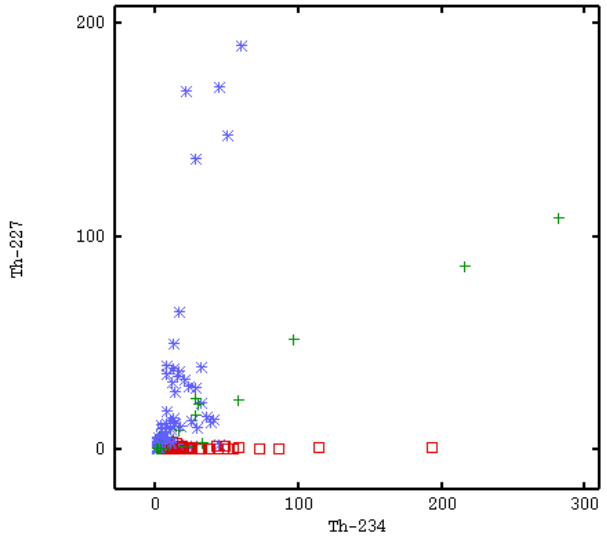
# CHARACTERISATION OF A DRUM LEGACY SITE

- **Context & Objectives:**
  - Legacy site on a former uranium mining pit
  - 80,000 drums with at least 3 different origins
  - Update of the site monitoring and understanding




- **Methods:**
  - Historical and functionnal analysis
  - Optimisation of the sampling strategy
  - Exploratory data analysis

- **Outcomes:**
  - Forecast of the number of drum layers and depth of natural ground, and monitoring of investigations
  - 3D reconstruction of the storage (aerial views, topographic maps, 2D gamma radiation scan…)
  - Identification of 5 drums origins (fingerprints)
  - Estimation of total activity




**Date: 2012-2013**

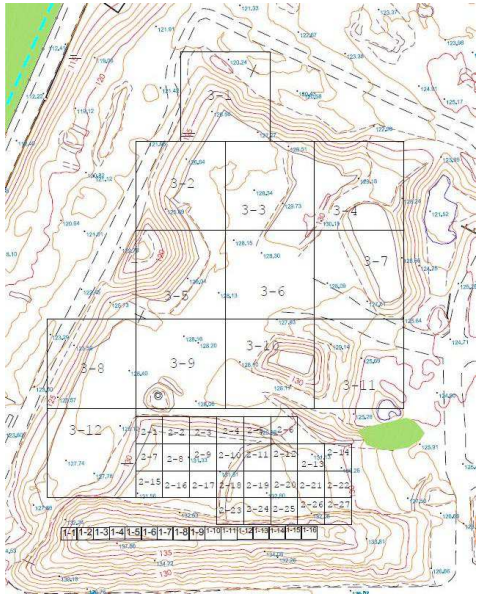
**Further reading:**

Himeur N., Desnoyers Y., Dubot D. (2013) Sampling optimization for the characterization of a drum disposal legacy site. In Proc. of Decommissioning Challenges > Industrial Reality and Prospects 2013 congress, Avignon, France.

Geovariances

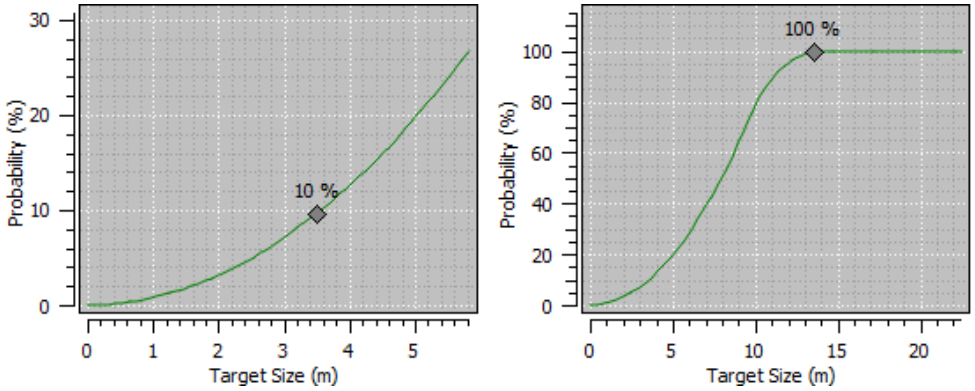
# STATISTICAL OPTIMIZATION OF SAMPLING

- **Context & Objectives:**
  - Controlling the absence of uranium contamination in gypsum deposit for mining authorization
  - Controlling the absence of uranium contamination in reworked embankment



- **Methods:**
  - Use of statistical tests and quantities to optimize sampling design (Marssim, Wilks, ISO TR 8550…)
  - Use of spatial consideration and geostatistical recommendations

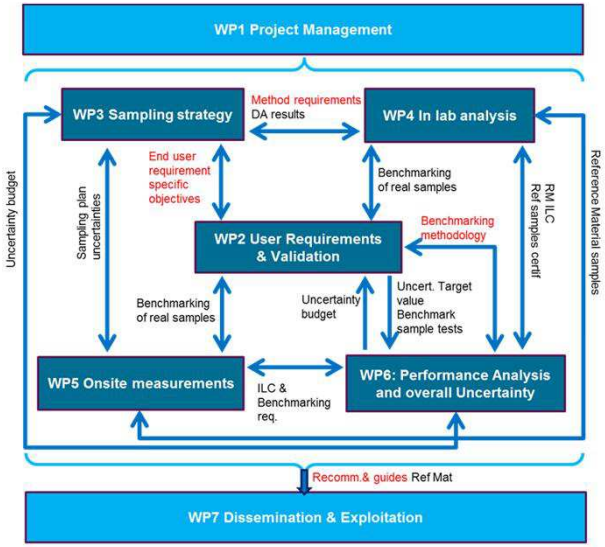
- **Outcomes:**
  - Better distinction between global estimate (statistics approach) and local characterization (spatial approach)
  - Optimization of the sample number to reach a 95% confidence level
  - Other recommendations taking into account spatial objectives (vertical resolution, probability of hitting a target…)




Date: 2018

Geovariances

- Designing new and validated characterization approaches devoted to constraint contexts
  - Minimize the total amount of waste and their categorization
  - Reduce characterisation cost and duration
  - Reduce dose to workers
  - Reduce environmental footprint….
- Sampling strategy optimization
- Coupling to suitable analytical techniques and methods
  - Performances
  - Global uncertainties
- Validation on real cases (3 use cases)
- Harmonization of the practices at European level

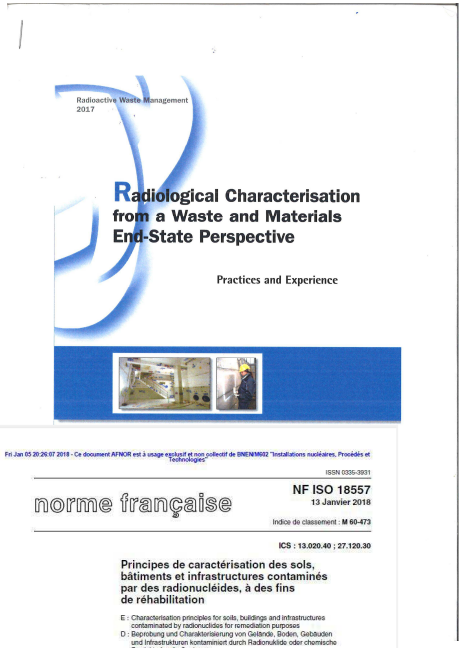


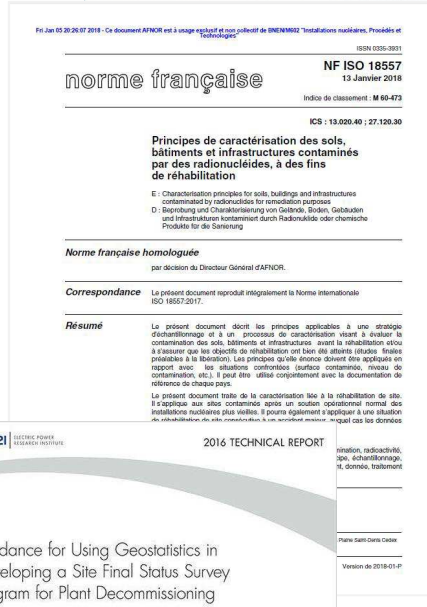

2017-2020

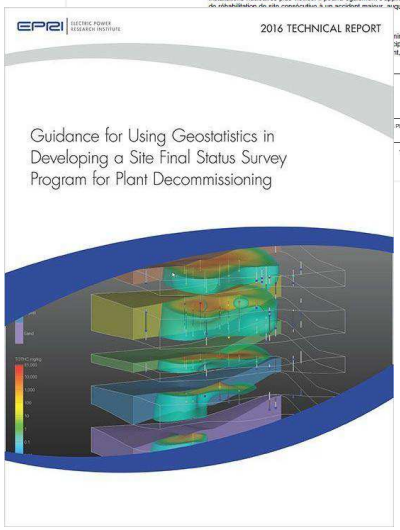
*This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 755554.*

Geovariances

- **Contribution to collaborative reports, guides and standards**
  - OECD/NEA - Working Party on Decommissioning and Dismantling (2017) *Radiological Characterisation from a Waste and Materials End-State Perspective* (www.oecd-nea.org/rwm/pubs/2017/7373-rad-char-pers.pdf)
  - ISO 18557:2017 *Characterisation principles for soils, buildings and infrastructures contaminated by radionuclides for remediation purposes* (www.iso.org/standard/62879.html)
  - CETAMA working group n°10 (2017) *Évaluation de l'état radiologique initial et final d'une installation nucléaire en situation d'assainissement* (CEA-R-6455 | ISSN 0429-3460)
  - EPRI (2016) *Guidance for Using Geostatistics in Developing a Site Final Status Survey Program for Plant Decommissioning* (www.epri.com/#/pages/product/3002007554/)
  - CETAMA working group n°10 (2014) *Soil Radiological Characterization Methodology* (CEA-R-6386 | ISSN 0429-3460)
  - OECD/NEA - Working Party on Decommissioning and Dismantling (2013) *Radiological characterisation for decommissioning of nuclear installations* (www.oecd-nea.org/rwm/docs/2013/rwm-wpdd2013-2.pdf)



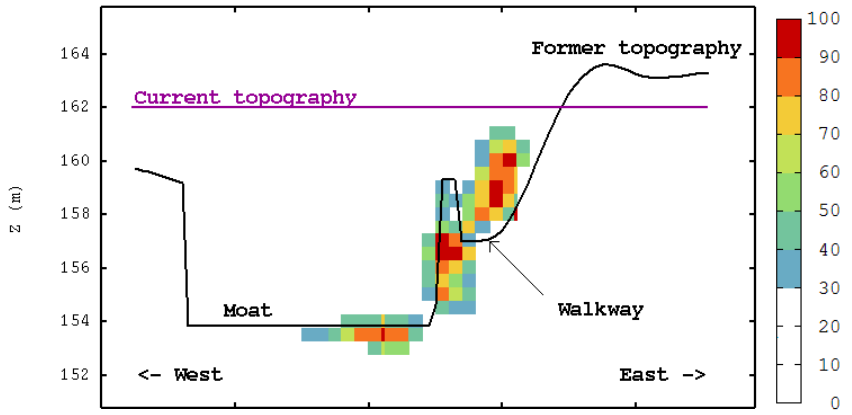



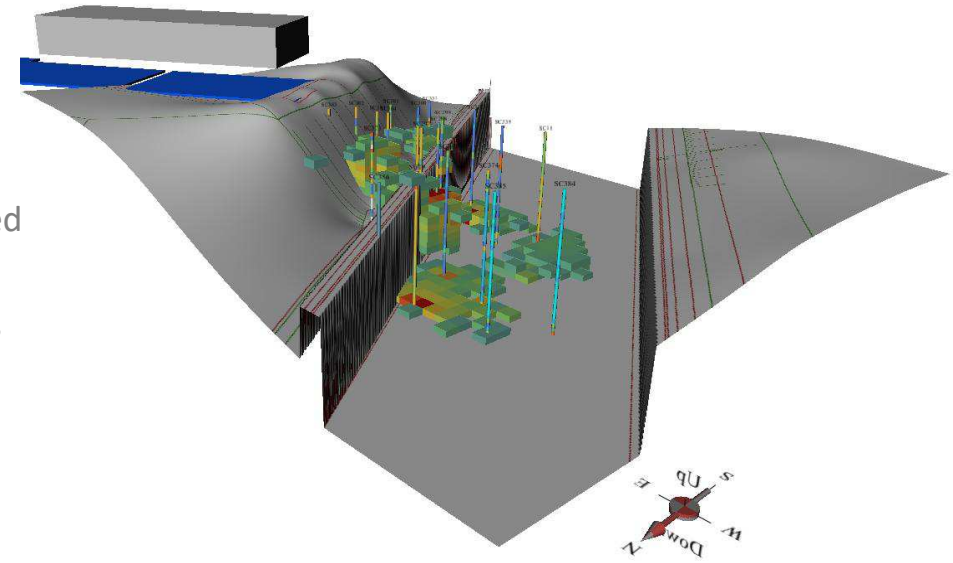




Geovariances

# RADIOLOGICAL CHARACTERIZATION OF SITES

- **Context & Objectives:**
  - Characterization of a deep radiological contamination with drill-holes (6 to 15 m, in 4 campaigns, 10 years long)
  - Integration of geostatistical processing and historical data
- **Methods:**
  - Linear interpolation of former topography
  - Contaminated volumes from probabilities of exceeding radiological thresholds
- **Outcomes:**
  - Avoiding wrong delineation of initially identified contamination (around 4 m depth)
  - Iterative data analysis to locate next drill-holes
  - Optimization of the excavation pit design



Date: 2010

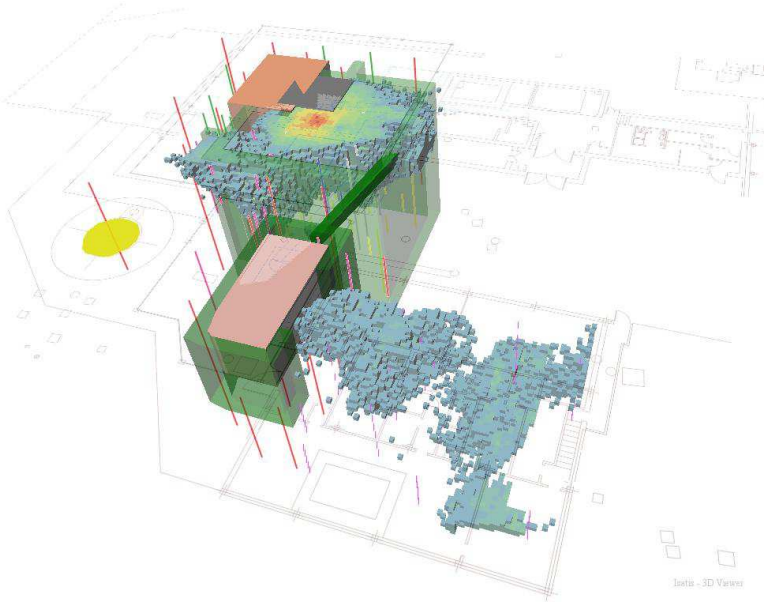
Further reading:

Desnoyers Y., De Moura P. (2011) Characterization Of A Deep Radiological Contamination: Integration Of Geostatistical Processing And Historical Data, in Proc. of ICEM 2011 congress, in press, Reims, France.

Geovariances

# RADIOLOGICAL CHARACTERIZATION OF SITES

- **Context & Objectives:**
  - Characterization of a deep radiological contamination with drill-holes (2 to 15 m, in 7 campaigns, 10 years long)
  - Integration of geostatistical processing and historical data
- **Methods:**
  - Exploratory data analysis to consolidate the heterogeneous database
  - Contaminated volumes from probabilities of exceeding radiological thresholds
- **Outcomes:**
  - Relevance of geostatistics methodology
  - Identification of uncertain areas according to classification thresholds
  - Recommendations about sampling strategies

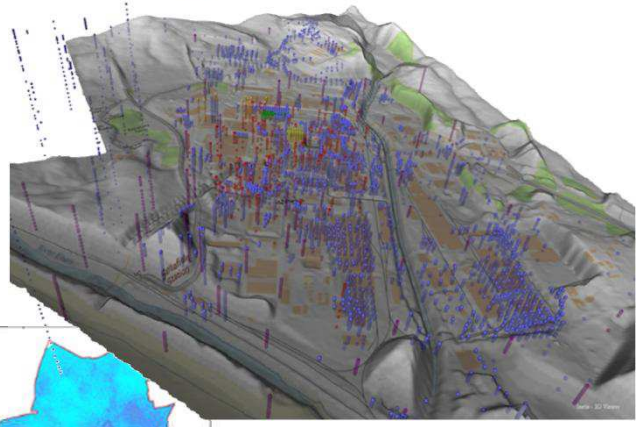
Date: 2013-2015

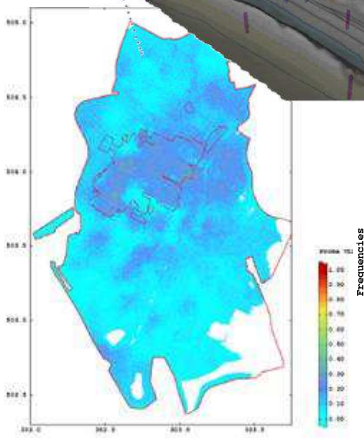
Geovariances

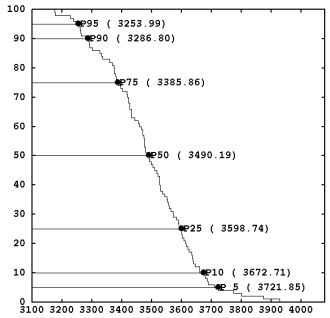
# SELLAFIELD SOILS AND GROUNDWATER

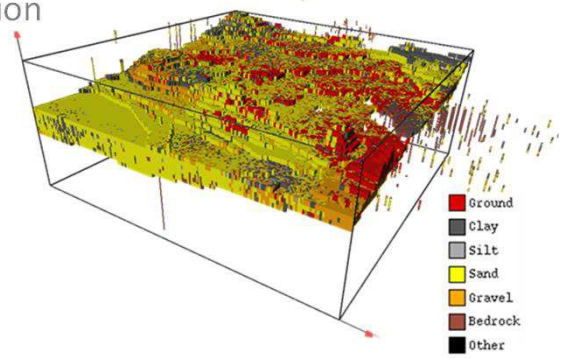
Sellafield Ltd

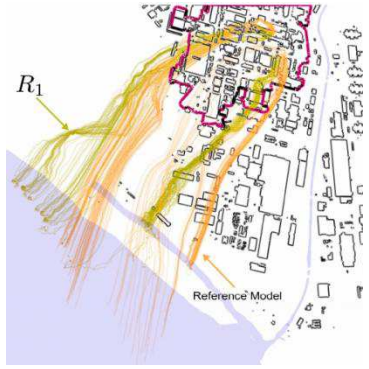
- Context & Objectives:
  - Understand and control the legacy of ground contamination to ensure protection of the workforce, the public and the environment
  - Use of most appropriate methods for the sampling and analysis of a large quantity of data gathered at public cost, over 30 years
- Methods:
  - Exploratory data analysis and variographic analysis
  - Risk curves on multivariate geostatistical simulations
  - PluriGaussian simulations to generate representative fields of permeability for flow and transport calculations
- Outcomes:
  - Estimation of the overall size and spatial distribution of the contamination with related uncertainty
  - Global (inventory) and local (maps) estimates
  - Better description of the geology heterogeneity






Date: 2014-2015

Further reading:


Faucheux C., Desnoyers Y., Jefferies N., Teasdale I., Cruickshank J. (2015) Geostatistics improvements for Sellafield contaminated soils and groundwater modelling. In Proc. of Global 2015, Paris, France.

Chautru J.-M., Desnoyers Y., Jefferies N., Jackson P., Teasdale I., Cruickshank J. (2015) Improvements with geostatistics for lithology representative fields and flow models at Sellafield site. In Proc. of AquaConSoil 2015, Copenhagen, Denmark.

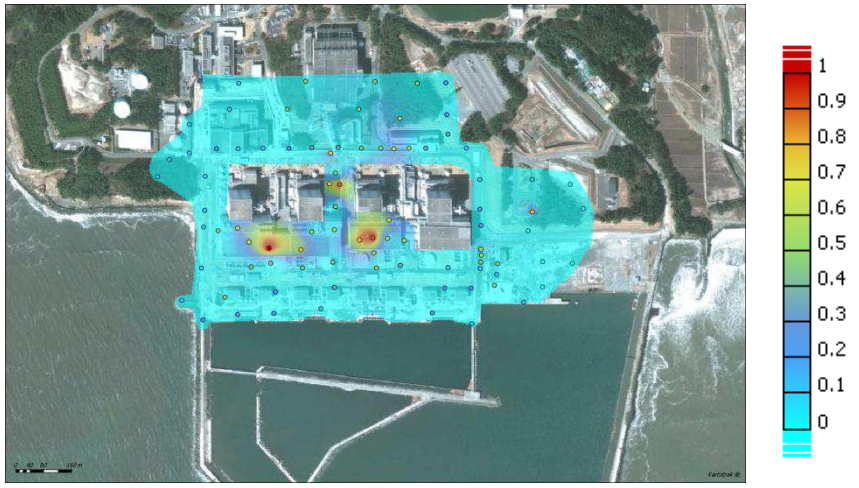

amec foster wheeler

Geovariances

# POST-ACCIDENTAL MAPPING (NPP SCALE)

- **Context & Objectives:**
  - Mapping of post-accidental areas
  - Protection of workers and surrounding people
  - Data collected by Tepco around Fukushima Daiichi Nuclear Power Station
- **Methods:**
  - Digitalization of survey maps
  - KARTOTRAK: GIS and Geostatistics-based software solution (integrated workflow)
- **Outcomes:**
  - Quick contamination mapping
  - Dose rate estimation for workers (risk maps)


Base map of radiation points (mSv/h)




Probability map of exceeding 10 mSv/h

Date: 2011

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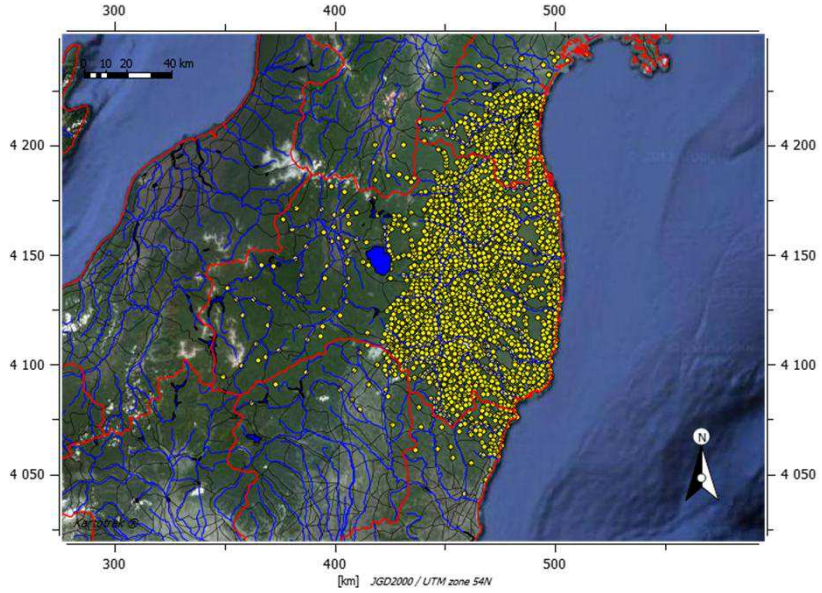
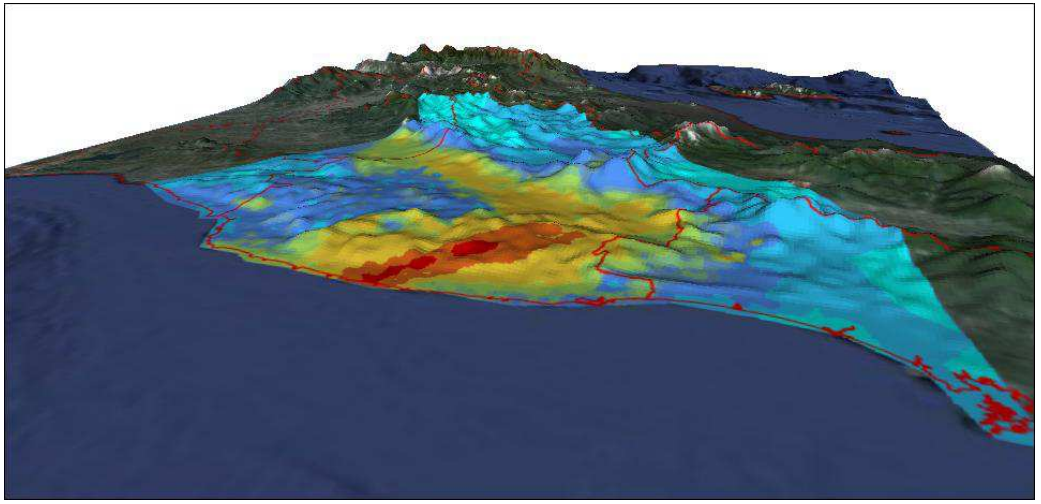
# POST-ACCIDENTAL MAPPING (LARGE SCALE)

- Context & Objectives:
  - Mapping of post-accidental areas
  - 2,000 dose rates collected by universities and MEXT in several prefecture after Fukushima Daiishi accident
- Methods:
  - KARTOTRAK: GIS and Geostatistics-based software solution (integrated workflow)
- Outcomes:
  - Under-sampled areas (risk maps)
  - Use of an elevation model to replace the contamination in its environmental context



Date: 2012-2013

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