Mathieu Le Coz (IRSN) / Léa Pannecoucke (Mines ParisTech) / Xavier Freulon (Mines ParisTech) / Charlotte Cazala (IRSN) / Chantal de Fouquet (Mines ParisTech)

Combining geostatistics and physically-based simulations to characterize contaminated soils

IRSN INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE
MEMBER OF ETSON

EUROSAFE 2019

Context

- How to **characterize contamination in soils or groundwater** when dealing with a polluted site needing remediation and with **a small amount of available observations**?

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Geostatistical estimation (kriging)	Direct flow-and-transport simulations
+ Observations honored	+ Physically-based model
- Physical information not taken into account	- Uncertainties in modeling parameters
- Performances limited if few data available	- Observations not honored

Outline

- Development of a method using physical information given by physically-based simulations into a geostatistical framework

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1. The Kriging with numerical variograms (KNV) method
2. A synthetic reference test case
3. Comparison of KNV to classical krigings

Kriging with Numerical Variograms (KNV)

- Development of a method using physical information given by physically-based simulations into a geostatistical framework:

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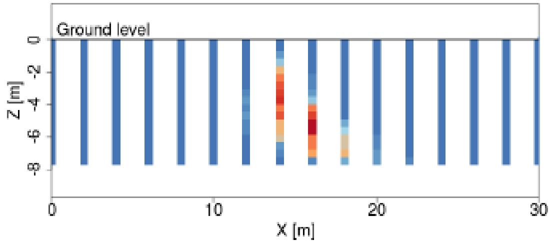
Kriging with Numerical Variograms (KNV)

Numerous observations



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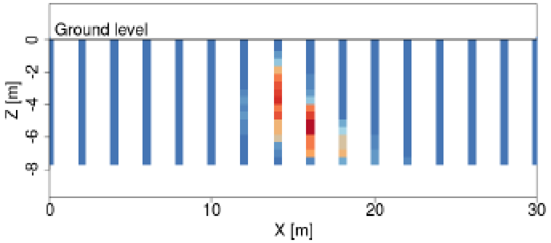
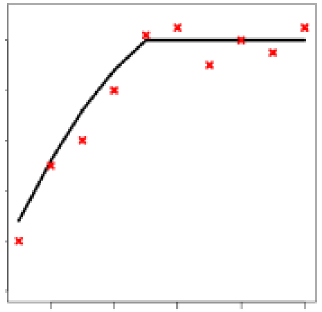


Variogram fitting



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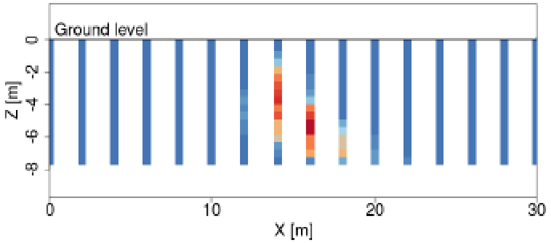

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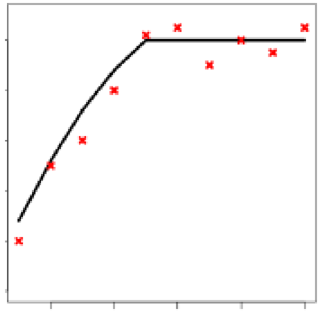

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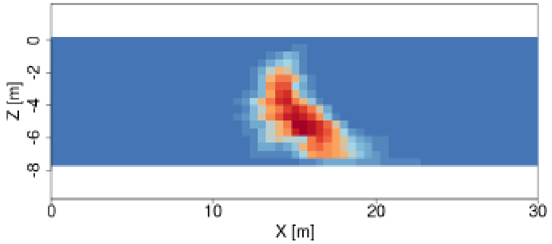

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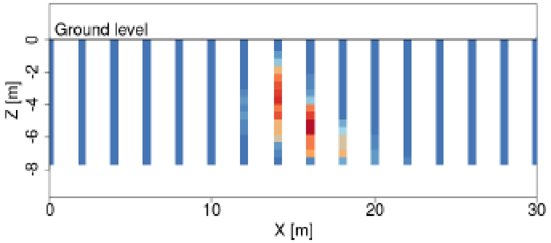

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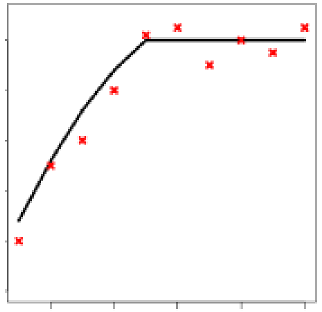

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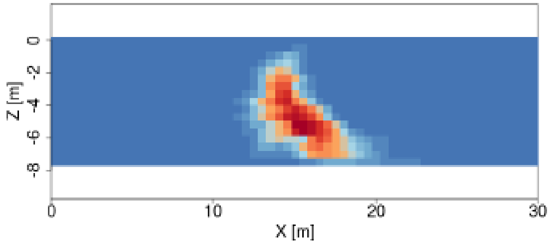

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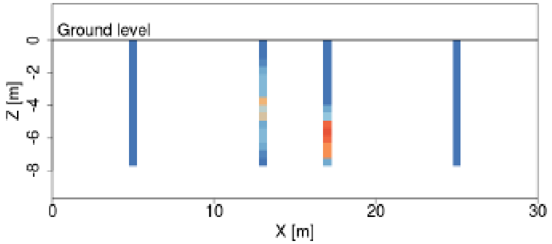

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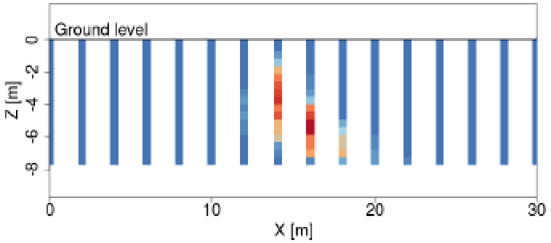

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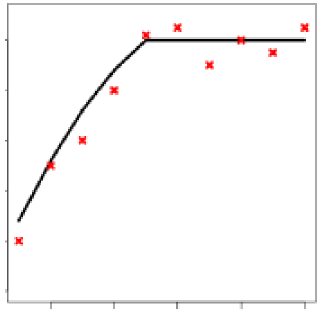

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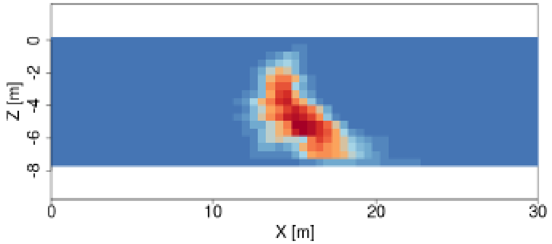

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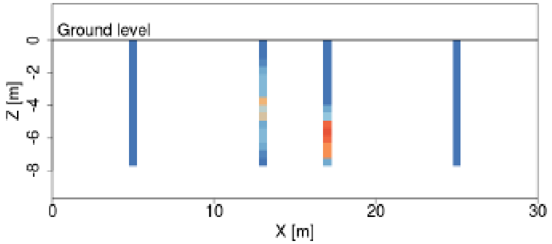

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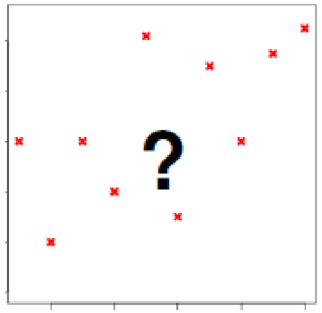

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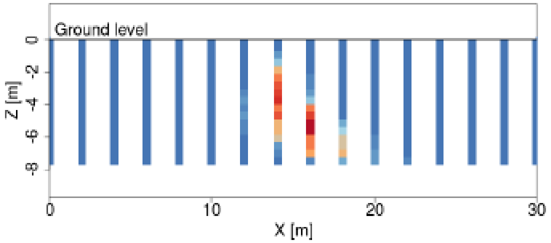

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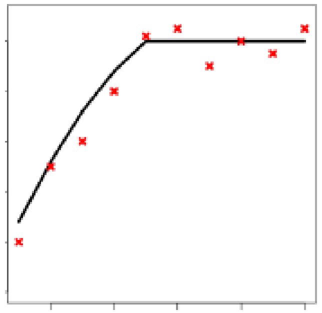

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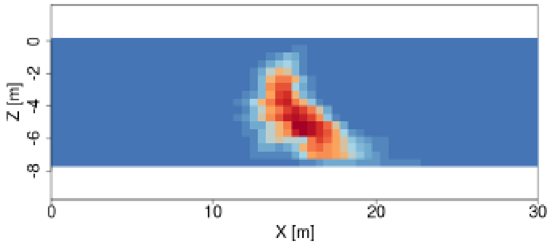

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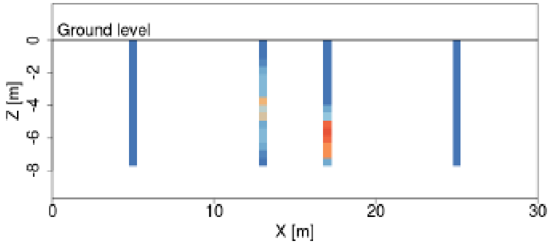

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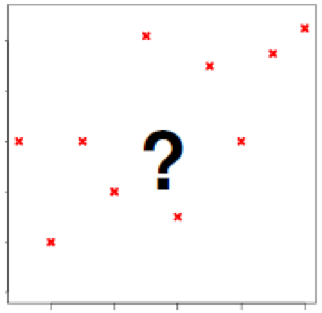

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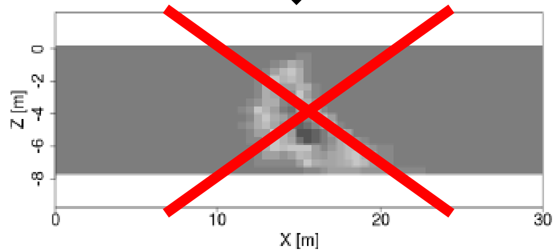

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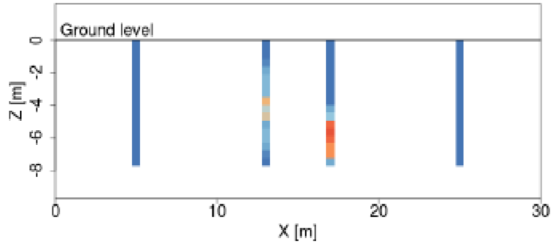
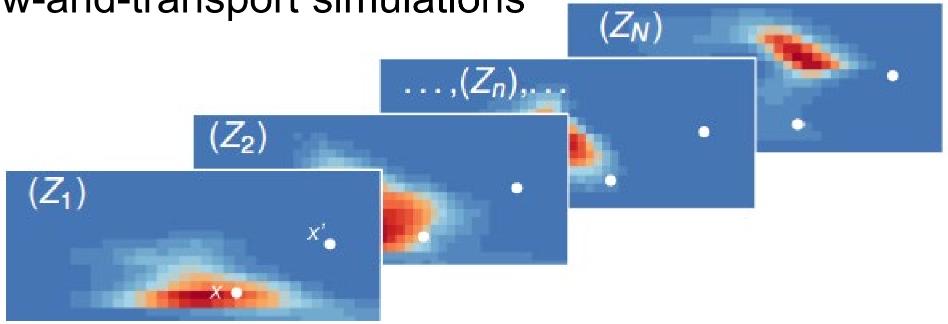


Kriging with Numerical Variograms (KNV)

Flow-and-transport simulations



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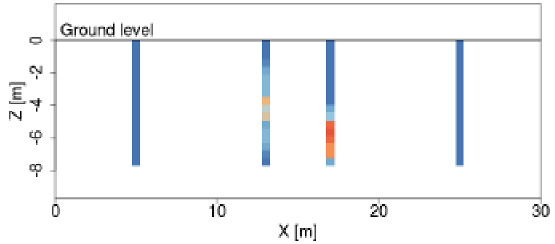

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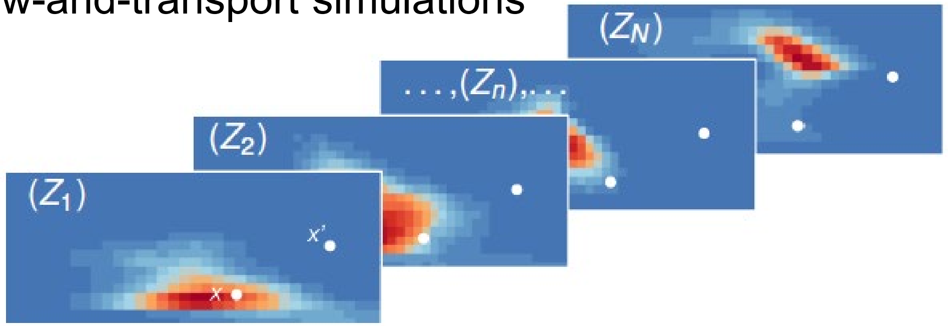

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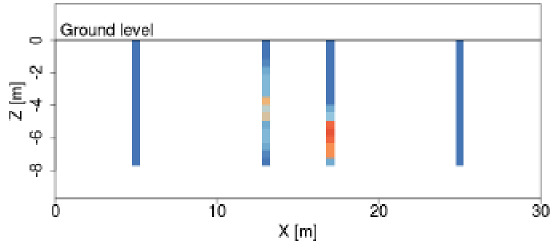

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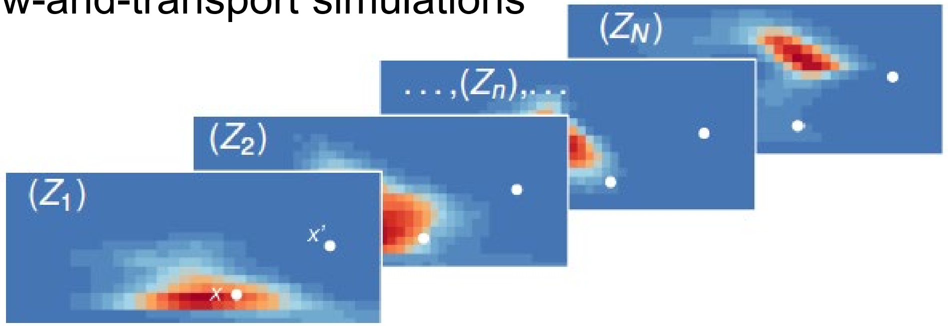

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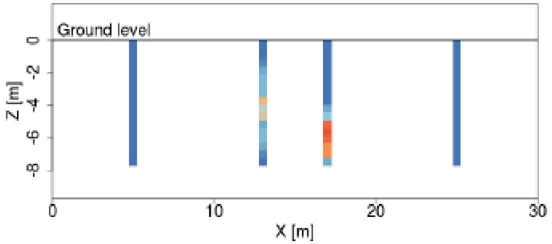

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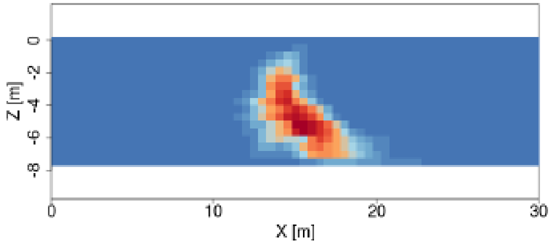

Synthetic reference test case

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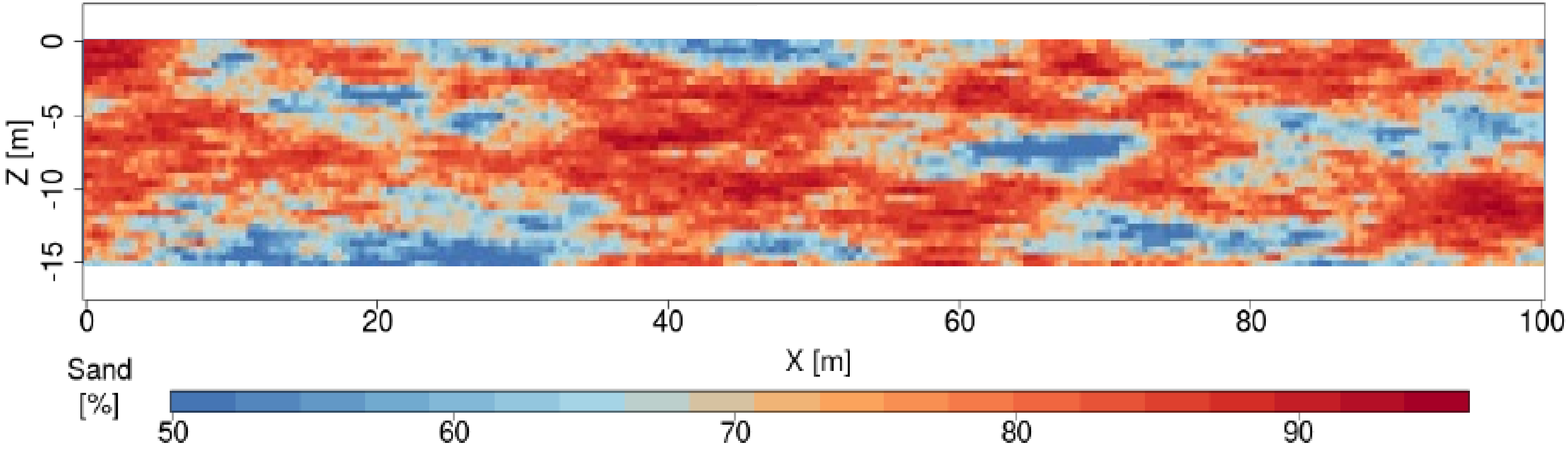
- Model settings (2D vertical section)

- Sandy loam facies with heterogeneous textural properties (i.e., sand, silt, clay contents);



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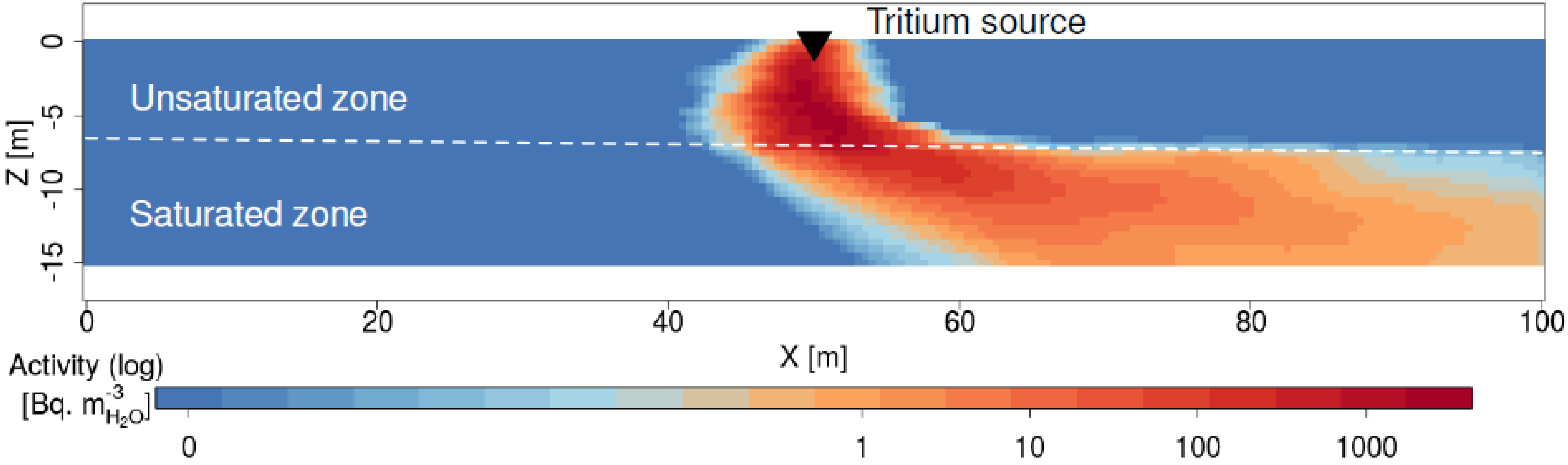

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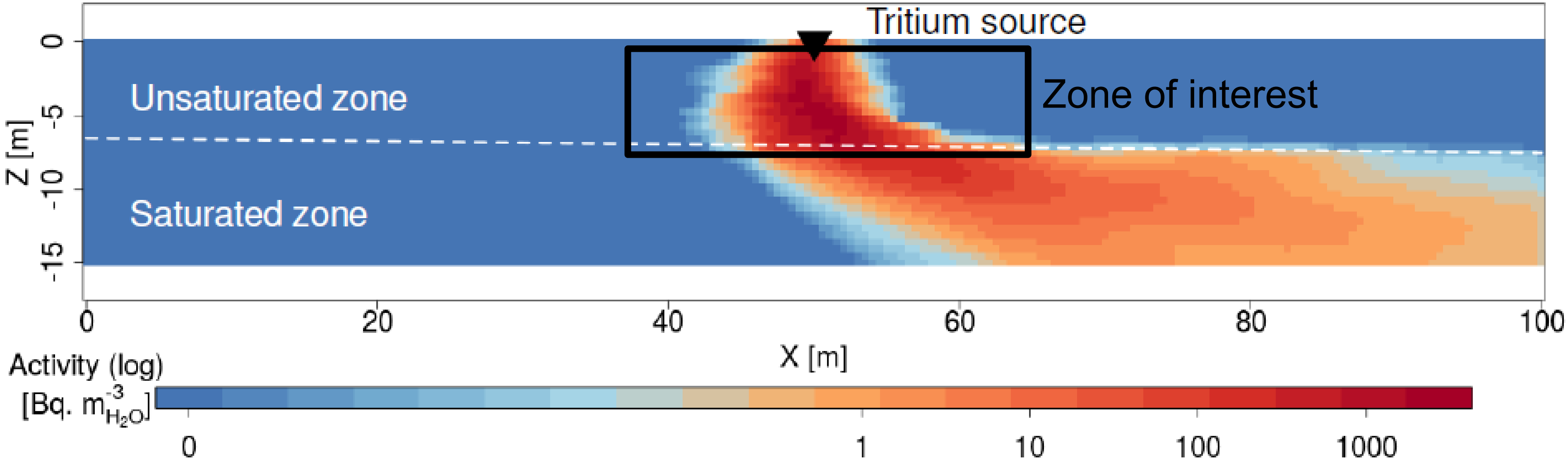

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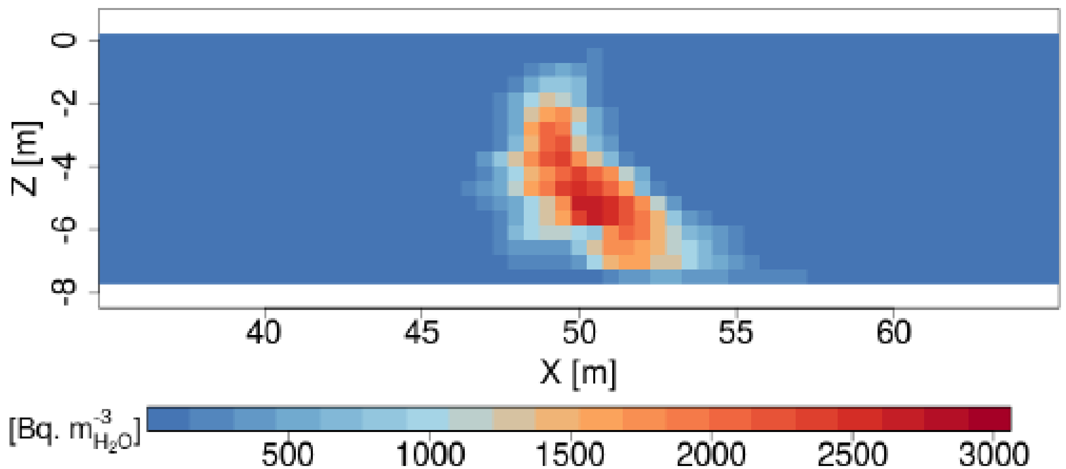
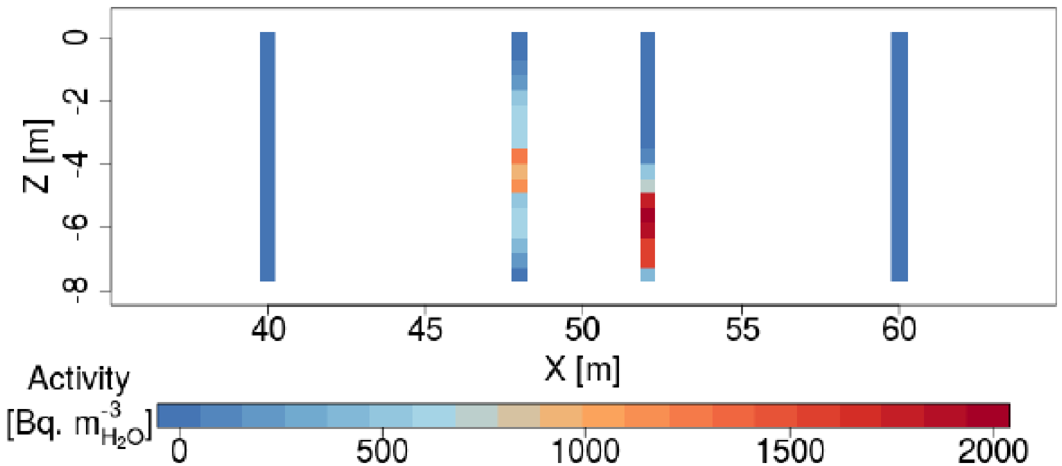


Synthetic reference test case

- Sampling scenario

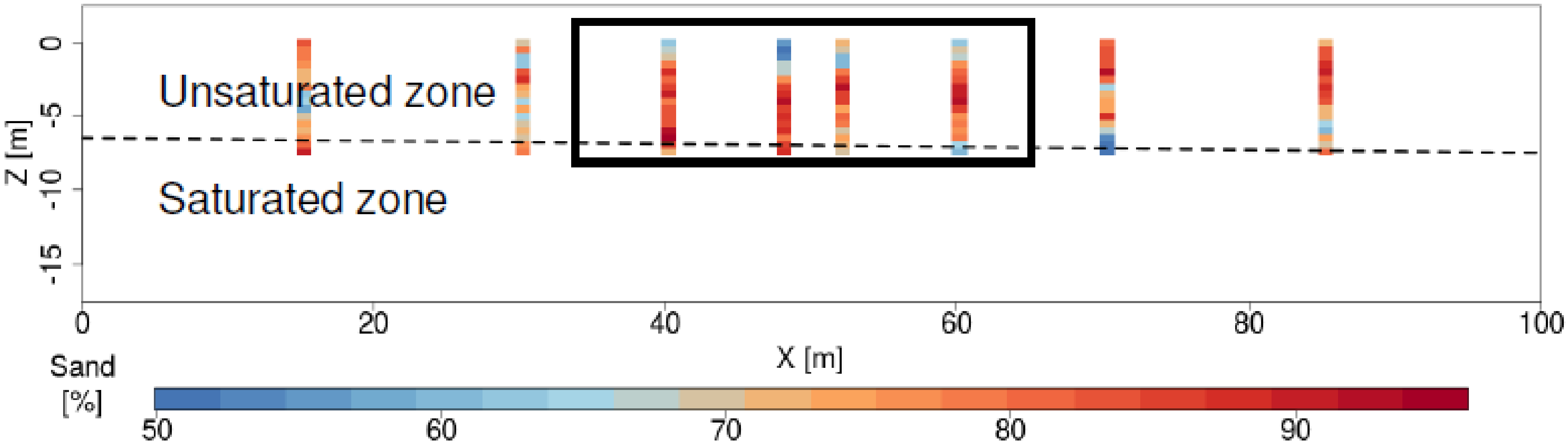
- 4 boreholes with activity;



Synthetic reference test case

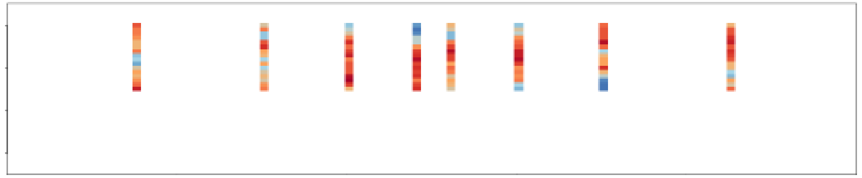
- Sampling scenario

- 4 boreholes with activity;
- 8 boreholes with soil texture.



Synthetic reference test case

Observations of texture



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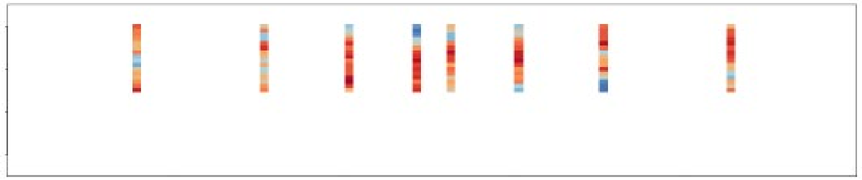
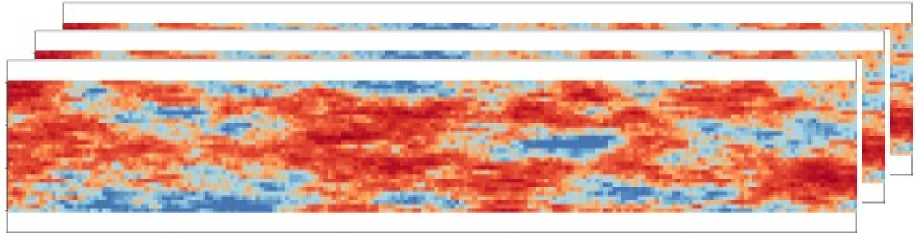


RGeostats ↓

Conditional simulations of texture



(×1000)

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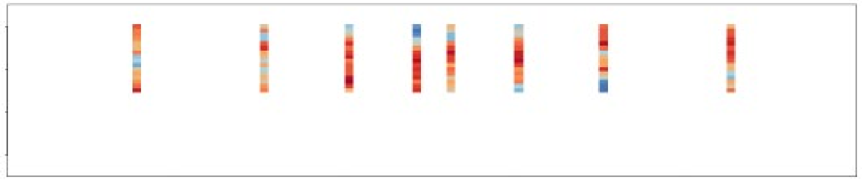
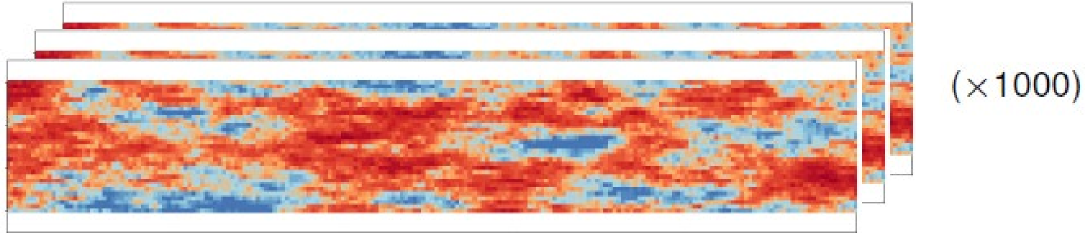
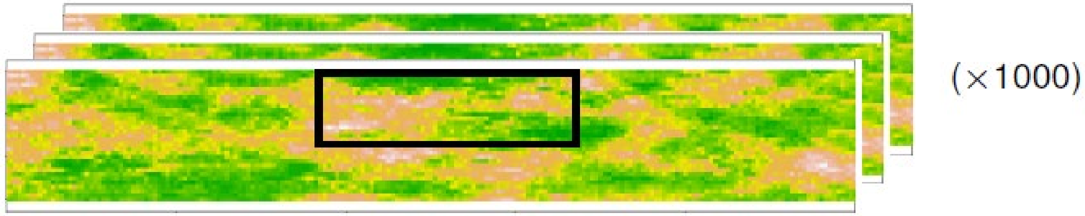
Rosetta PTF

Conditional simulations of hydraulic parameters







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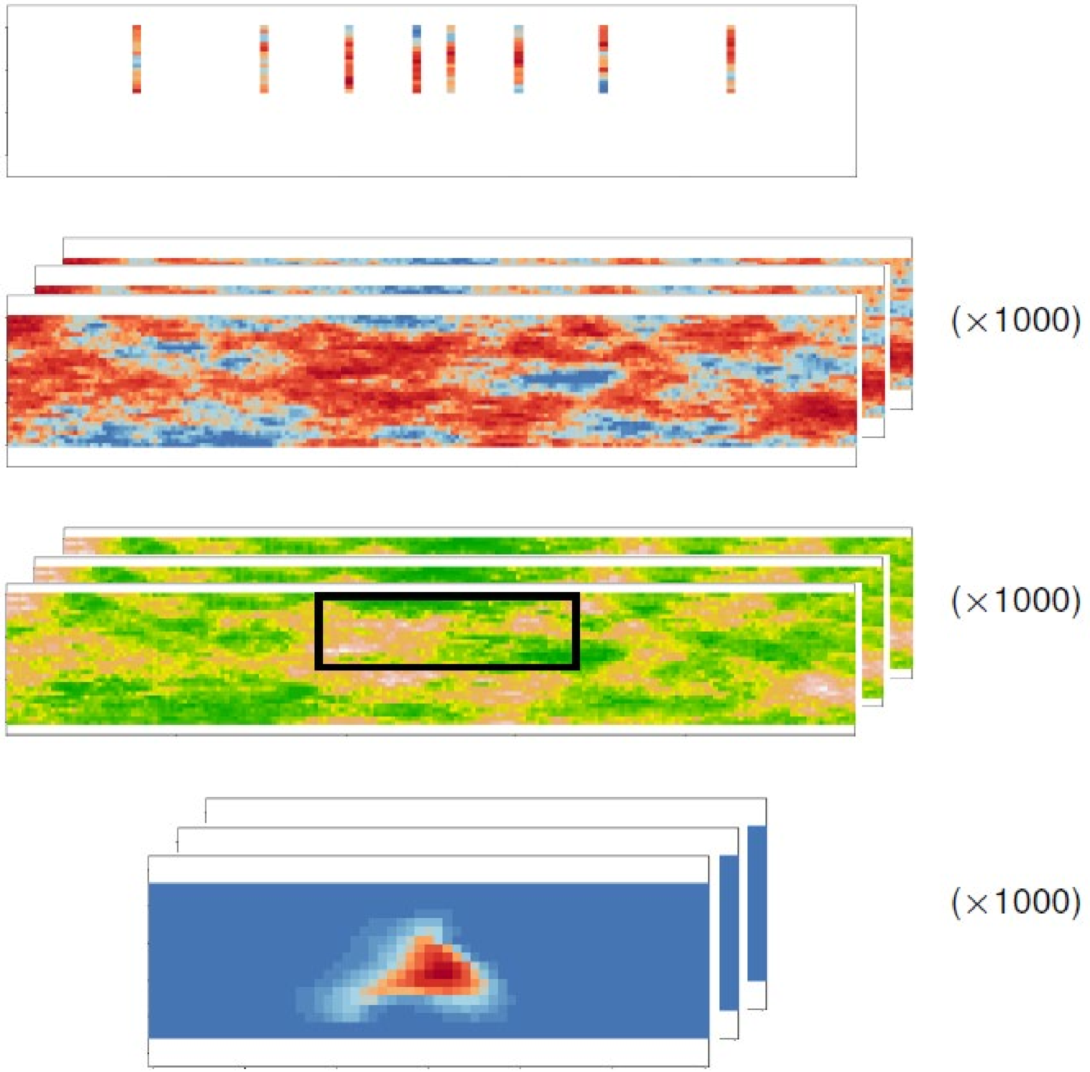
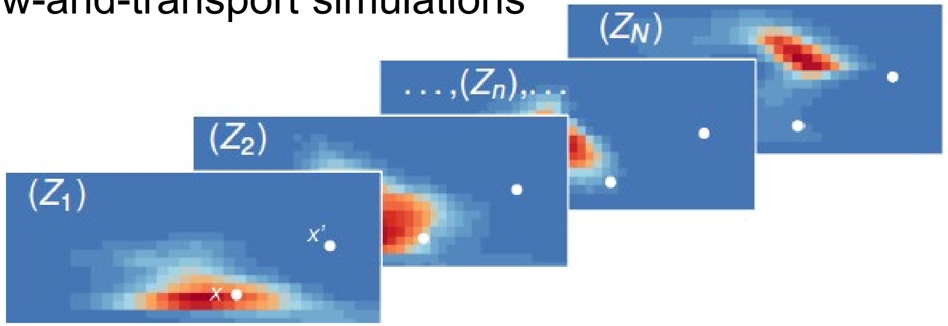
MELODIE

Simulations of tritium plume



Synthetic reference test case

Flow-and-transport simulations



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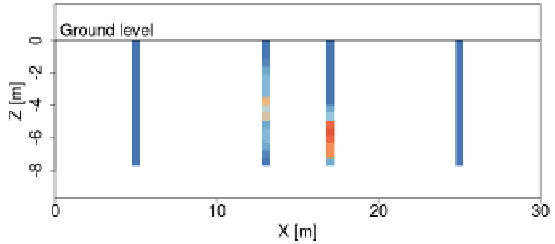
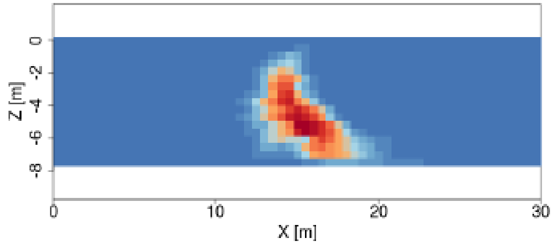


Kriging



KNV vs. classical krigings

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KNV vs. classical krigings

- **Ordinary kriging (OK)**, which is widely used but known to perform poorly when the number of data is too small or when the phenomenon under study is complex;
- **Kriging with external drift (KED)**, which enables the incorporation of auxiliary variables to take non-stationarity into account.

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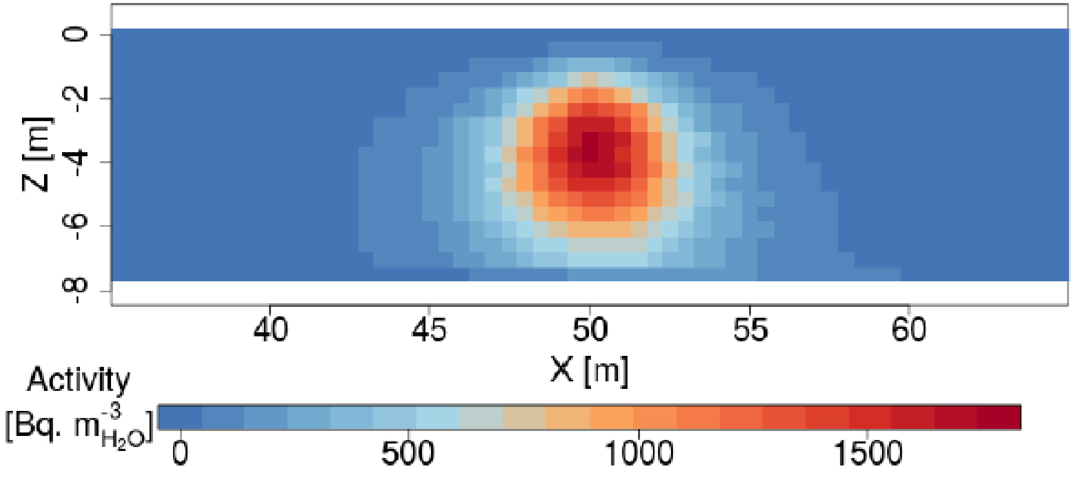
Auxiliary variable: empirical mean of set of simulations



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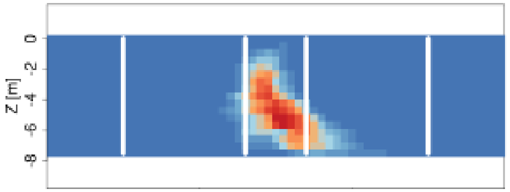
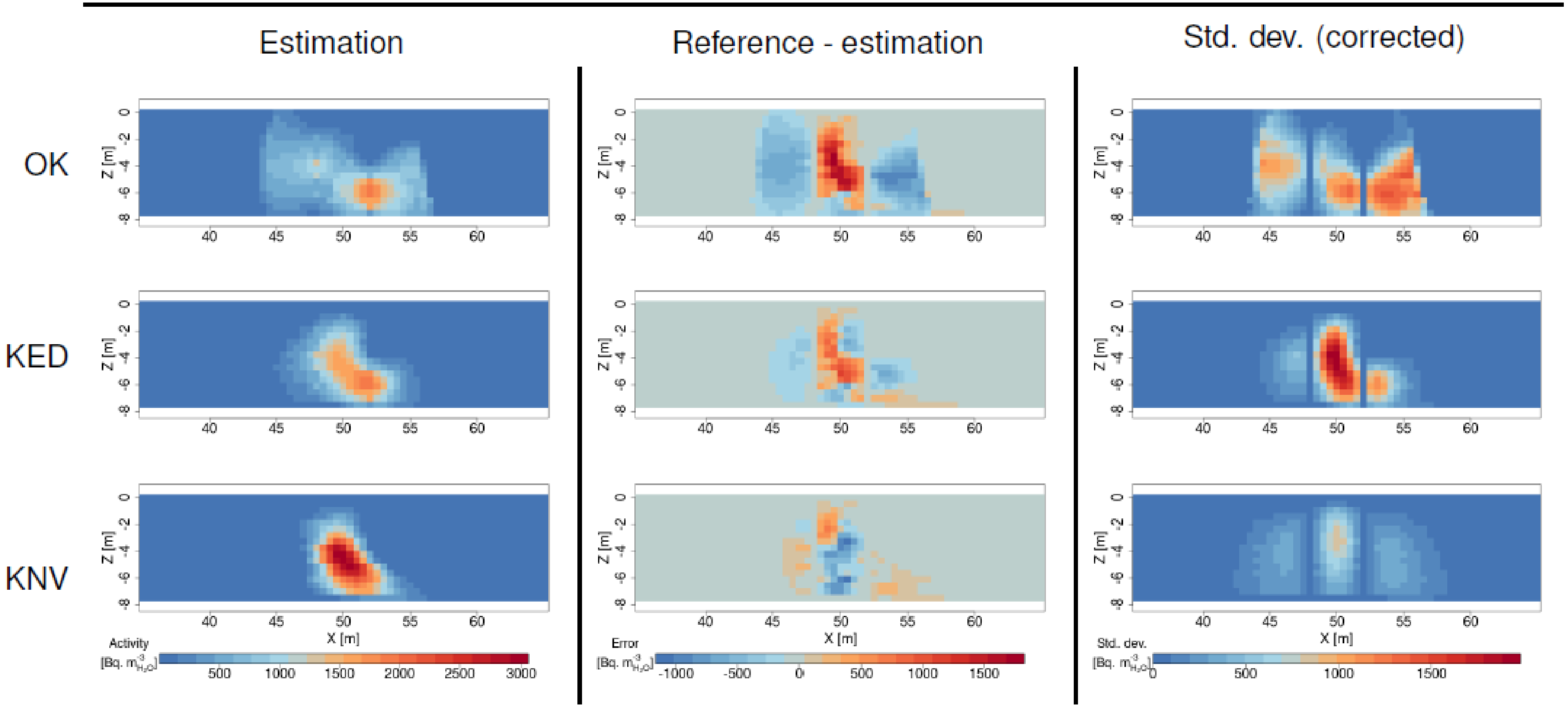


Reference tritium plume



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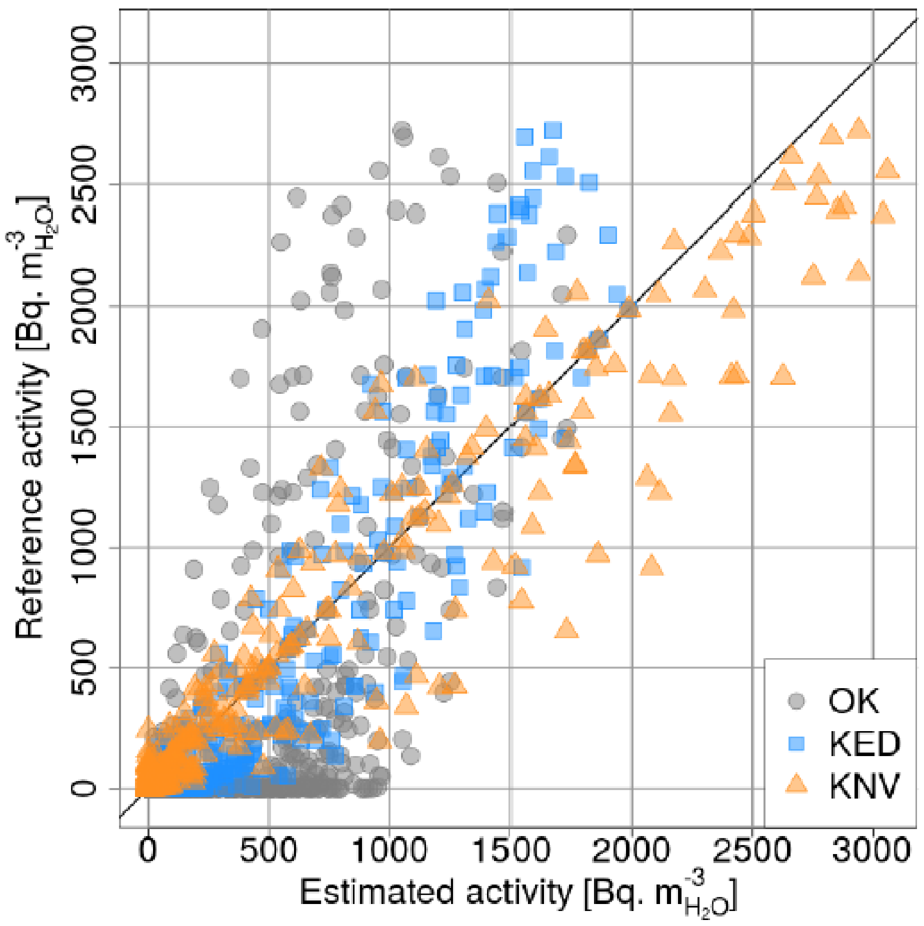
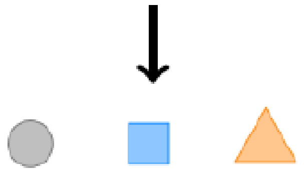


1 point of the domain



Global statistics

	OK	KED	KNV
MAE [Bq.m^{-3}$_{H2O}$]	173	71	**47**
RMSE [Bq.m^{-3}$_{H2O}$]	348	174	**147**
MRE [-]	-47	-6.8	**-0.8**

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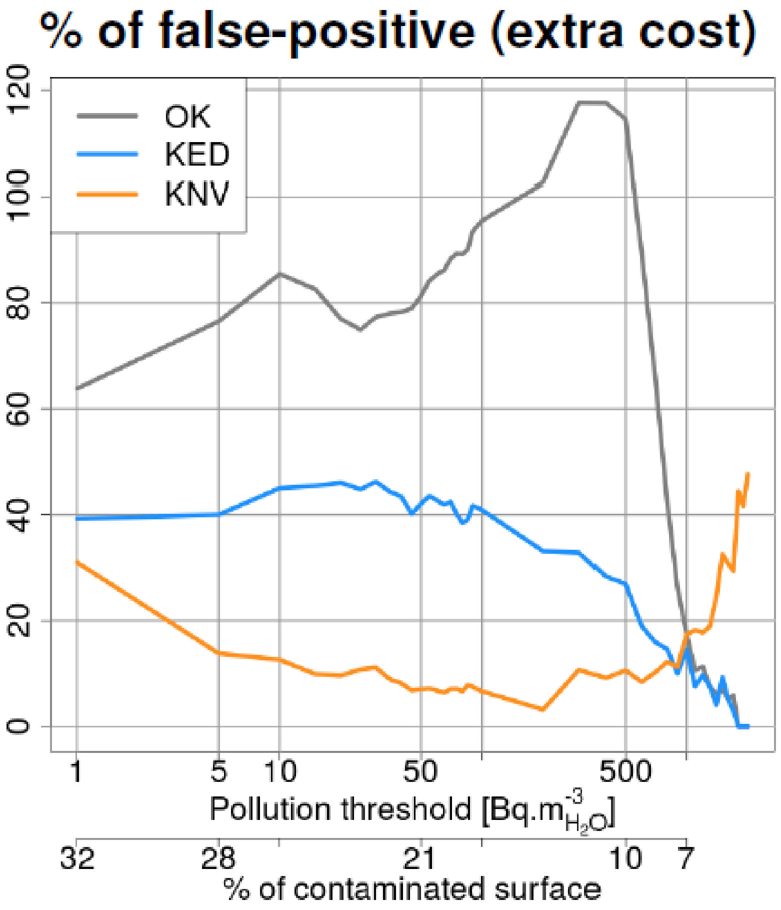

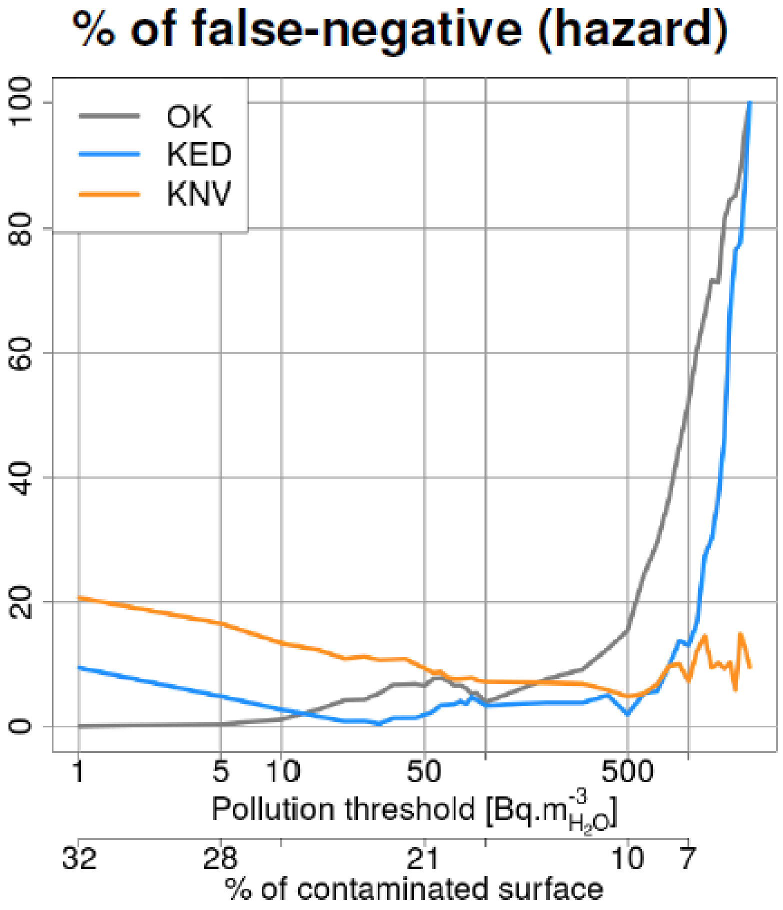

Conclusion

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- Ongoing work: implementation on a real 3D study-case…

Thank you for your attention

This study is a part of Kri-Terres project, supported by the French National Radioactive Waste Management Agency (ANDRA) under the French "Investments for the Future" Program.