Numerical Simulations for Radioactive Waste Disposal NSRAWD

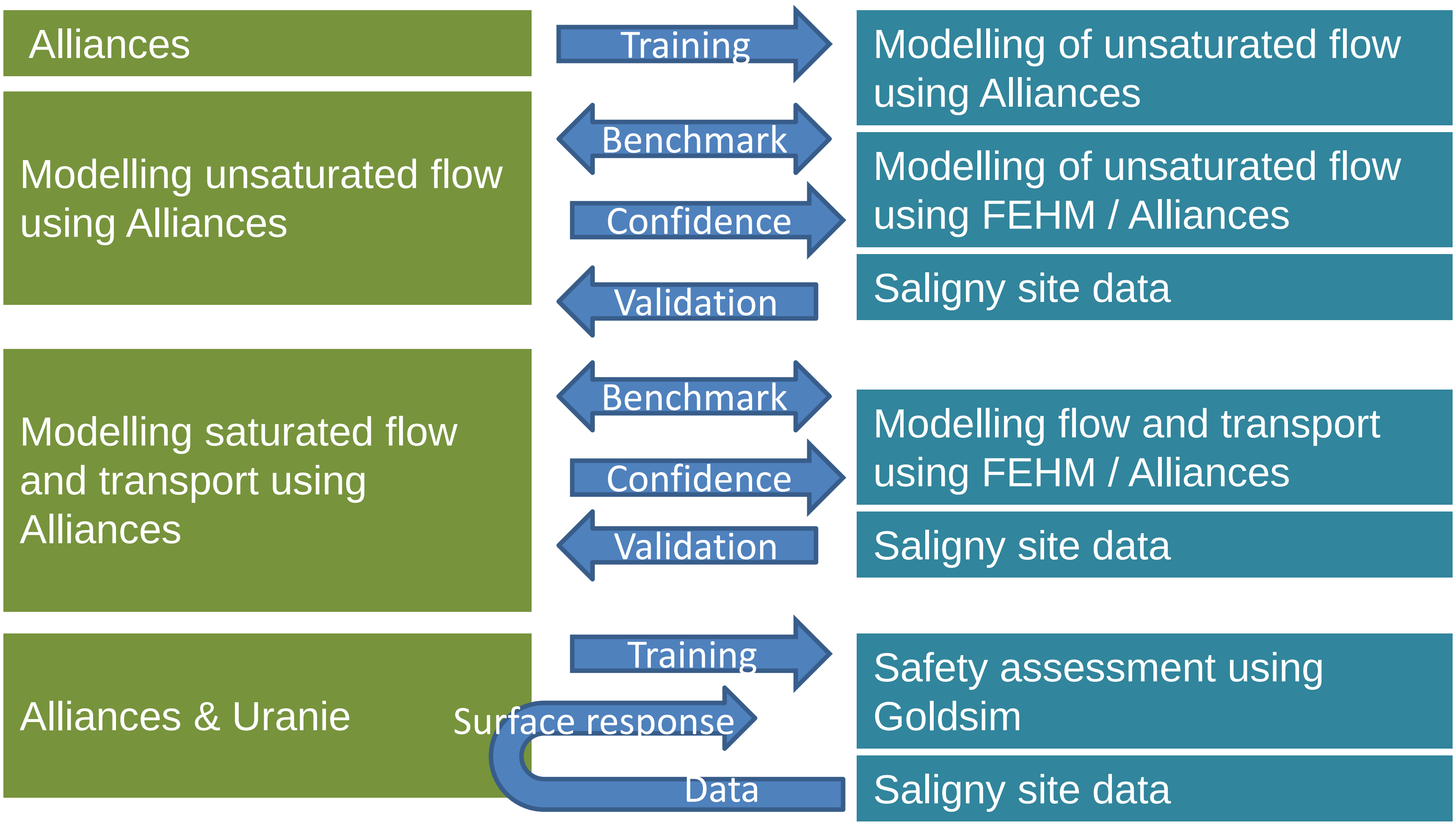
Scope of the project

Develop numerical simulation for radioactive waste disposal (LILW), combining computational work with experimental activities in order to improve and validate flow and transport numerical models.

Objectives:

- Improve and validate flow and transport numerical models and codes used in disposal safety assessment at Saligny.
- Develop new in-field test and collect experimental data for Alliances codes validations and for better understanding of site characteristics.
- Increase confidence in the numerical modelling used in radioactive waste disposal.
- Develop an integrated system for safety assessment of LIL waste disposal applied to Saligny site as an useful tool for further application in the site licence.

Task sharing

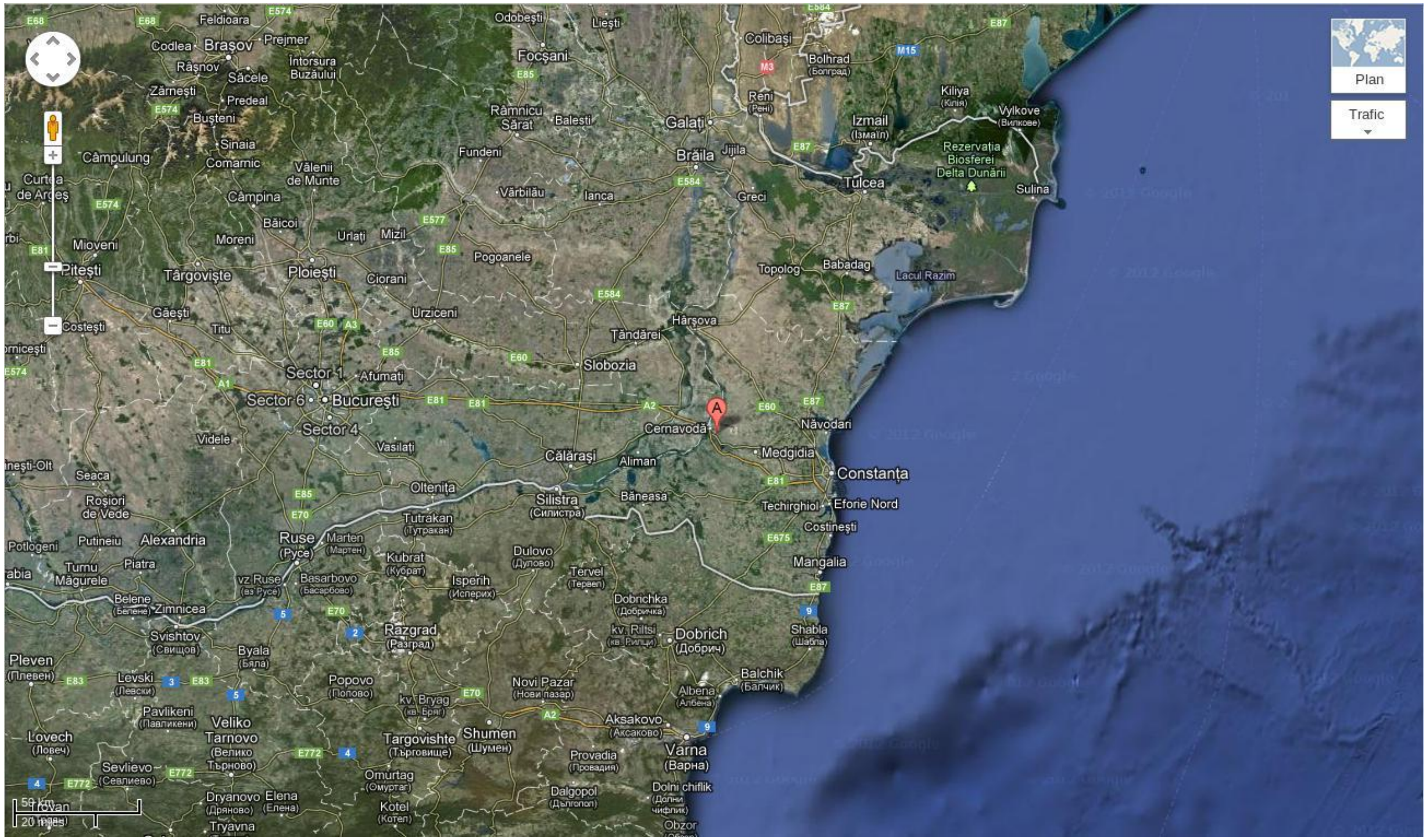


Progress (1/7)

The Saligny site

Progress (1/7)

The Saligny site



Progress (1/7)

The Saligny site

Progress (1/7)

The Saligny site

Progress (1/7)

The Saligny site

Progress (2/7)

Saligny site modeling objectives

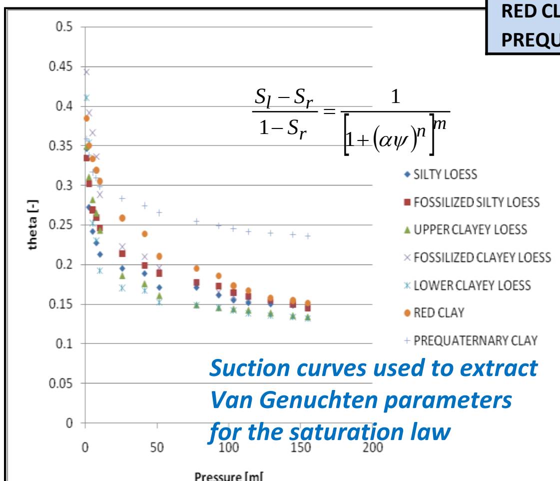
- modeling unsaturated flow in the vadoze zone.
  - > Richard's Equation.
- modeling transport in the vadoze zone (transfer time)

Stratification of soil layers

Selection of the suction curves was made in order to match optimally the average saturation and pressure for each layer

Layer	average saturation[-]	average pressure [m]	theta_s (porosity)[-]
SILTY LOESS	0.2700	46.0	0.4141
FOSSILIZED SILTY LOESS	0.4725	37.0	0.3852
UPPER CLAYEY LOESS	0.3575	33.0	0.4097
FOSSILIZED CLAYEY LOESS	0.5500	29.5	0.3944
LOWER CLAYEY LOESS	0.3711	23.5	0.4132
RED CLAY	0.7275	17.0	0.3935
PREQUATERNARY CLAY	0.8400	7.27	0.3755

Input data directly extracted from the database



Suction curves used to extract Van Genuchten parameters for the saturation law

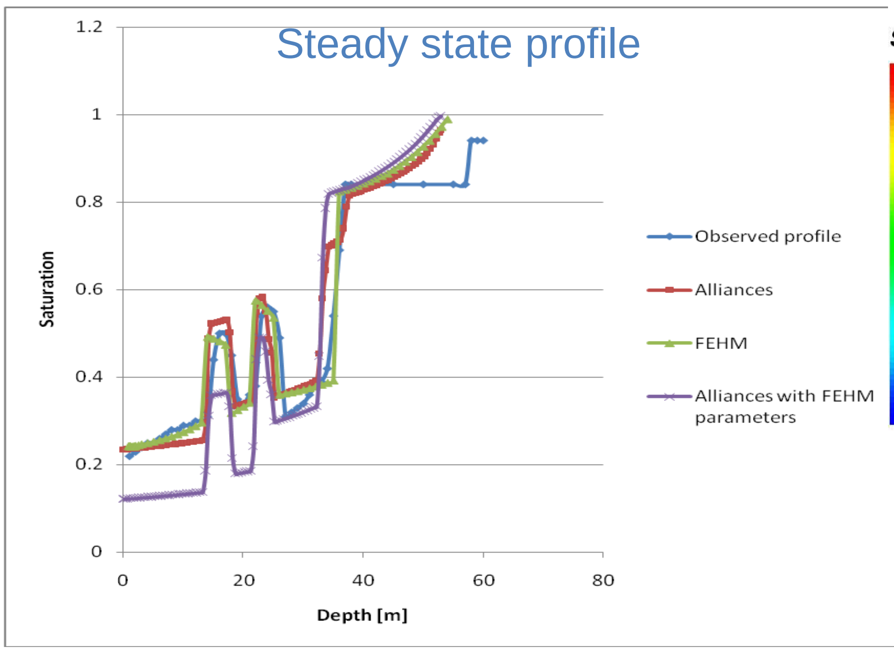
Van Genuchten parameters

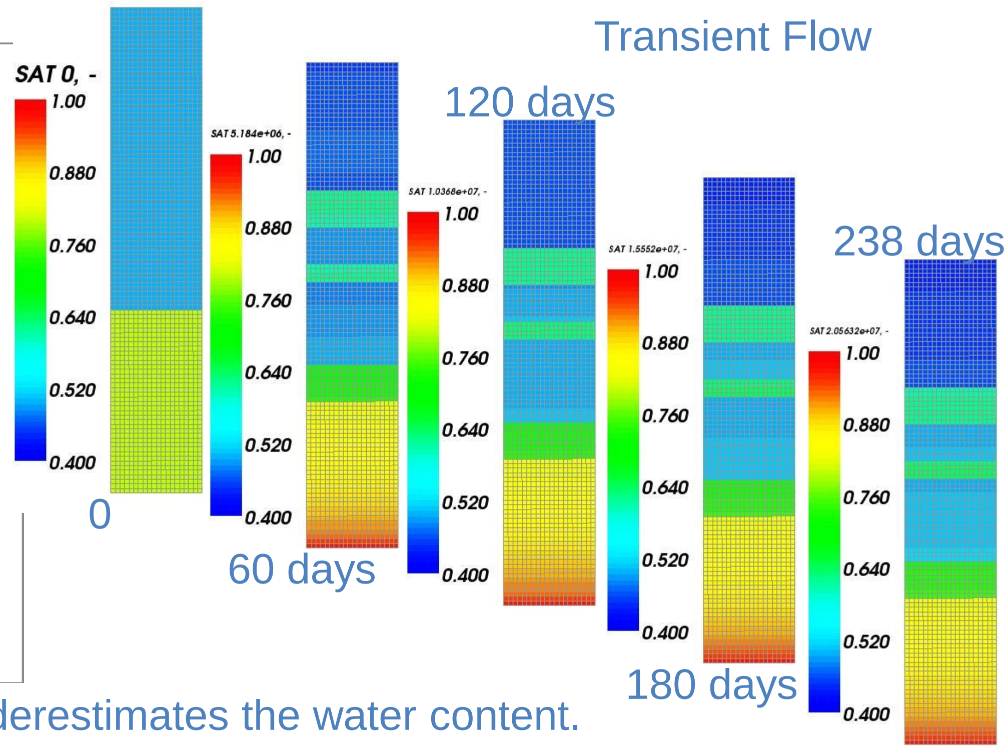
Layer	alpha	n	m	theta_r
SILTY LOESS	2.3425	14.8846	0.0204	0.0968
FOSSILIZED SILTY LOESS	0.0010	0.4700	3.3700	0.0272
UPPER CLAYEY LOESS	0.2553	0.7594	0.6096	0.0727
FOSSILIZED CLAYEY LOESS	0.0059	0.4867	1.5236	0.0017
LOWER CLAYEY LOESS	0.0004	0.3873	6.2282	0.0682
RED CLAY	0.0296	0.7244	0.7204	0.0111
PREQUATERNARY CLAY	0.0001	0.4300	2.8000	0.0092

Progress (3/7)

Unsaturated flow modelling objectives

- Inter-comparison of Alliances and FEHM predictions with experimental data (validation)
- Get in-field data (calibration) on unsaturated flow





- using same input parameters - Alliances underestimates the water content.
- need to develop further modeling of test case using FEHM and Alliances

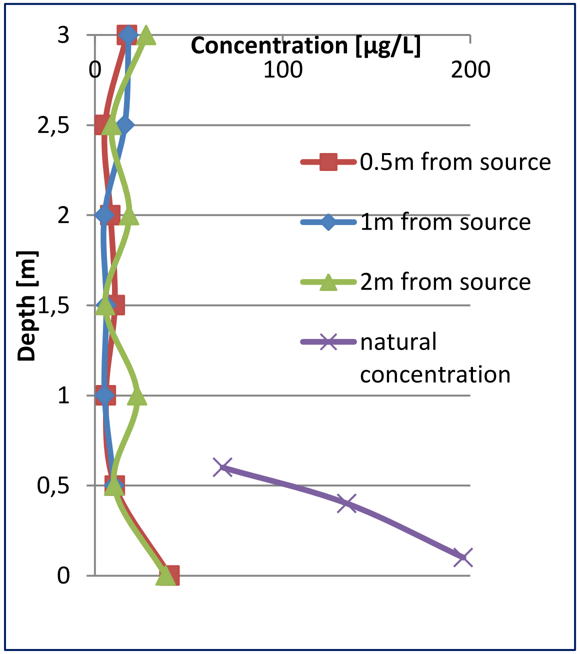
Progress (4/7)

Tracer test objectives
- get in-field data on chemical species migration

Status :
- designed, planned and launched
  - *tracer: Iodine (KI)*
  - *concentration: 20 mg/l*
  - *depths: 50 cm*
  - *location: meteo station*
  - *launched: 01/09/2011*
  - *sampling: 20/06/2012*

Results obtained

✓Natural value of iodine concentration are much higher than in samples tested for iodine dispersion probably due to iodine sorption in organic material nearby soil surface

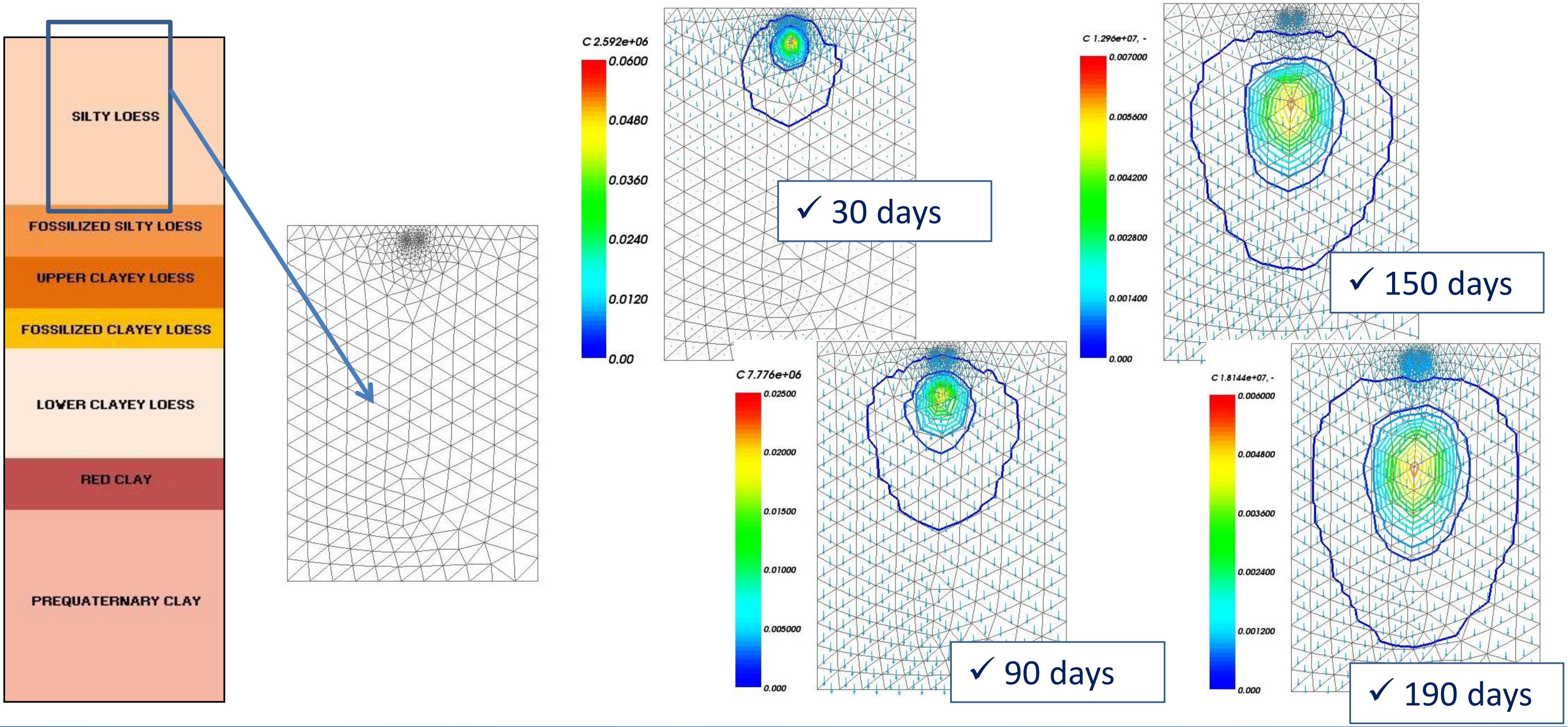


✓comparing the values obtained with iodine concentrations previously measured at depths > 10m (between 5 and 10 µg/L), iodine transport is very slow and not influenced by the tracer launched

Progress (5/7)

Tracer test objectives
- validate transport models for reactive transport

Status :
- tracer transport simulations



Progress (6/7)

Neural networks approach to response surface methodology

Objectives

- Compute a response surface that allows to predict output variables <u>much faster</u> than with the computer code in order to perform statistics, uncertainty analysis, influent parameters selection …

Status :

Alliances training session (09/2012) performed by CEA for INR in using Uranie module for response surface construction.

- First step : the computer code is launched several times according to an experimental design in order to create the neural network (learning database + testing database) used for response surface construction.

- Second step : After neural network is done, the output of any combination of the input variables set in the experimental design can be predicted without running the code.

Progress (7/7)

Example test

Unsaturated flow in two-layered vertical soil.
→ Saturation dependence on layers permeability.

Top Layer

Width: 10m
Porosity: 0.4141
θ_r: 0.162
VG α: 0.634 [1/m]
VG n: 1.640
VG m: 0.390

Bottom Layer

Width: 5m
Porosity: 0.3852
θ_r: 0.127
VG α: 0.935 [1/m]
VG n: 1.297
VG m: 0.228

Set of conditions

Initial conditions:
Eff saturation = 0.5 in **Top Layer**
Eff saturation = 0.8 in **Bottom Layer**

Boundary conditions:
Eff saturation = 0.4 on top of the **Top Layer**
Eff saturation = 0.7 on bottom of the **Bottom Layer**

Experimental design

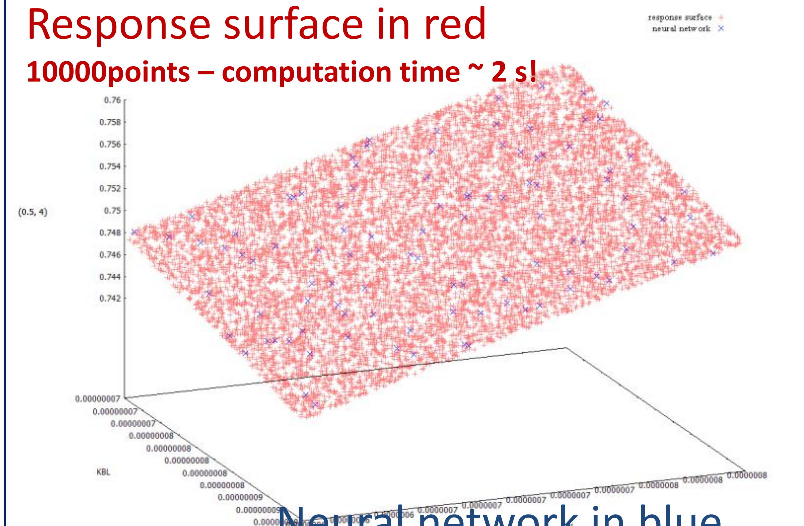
Permeability Top Layer in [6E-7, 8E-7], uniform
Permeability Bottom Layer in [7E-8, 9E-8], uniform

LHS Sampling

Output

saturation in point (0.5, 4)

Response surface in red
10000points – computation time ~ 2 s!



Neural network in blue
100 points – computation time ~ 30 min

Perspectives of collaboration

Under the project

- Hydraulic modelling in the Saligny aquifer.
- Transport modelling in the vadoze zone on the Saligny site and benchmarking.
- Model transport using surface response build by Uranie module inside Alliances.

Beyond the project

- Joint studies on the hydro-geological and hydro-chemical modelling of the Saligny site.
- Joint modelling of alternative subsurface radioactive waste disposals and analysis of different scenarios.

Benefits

• Improve and validate flow and transport numerical models and codes used in disposal safety assessment at Saligny.

• Improve site characterisation and better understanding of transport processes.

• Increase confidence in the numerical modelling used in safety assessment of radioactive waste disposal.

• Improve and validate flow and transport numerical models used by Alliances platform based on experimental data.

• Promote a larger use of Alliances platform and transfer knowledge on radioactive waste modelling.

• Increase confidence in the numerical modelling used in radioactive waste disposal.