Overview of advantages and drawbacks of different methods for sensitivity analysis in the context of performance assessment

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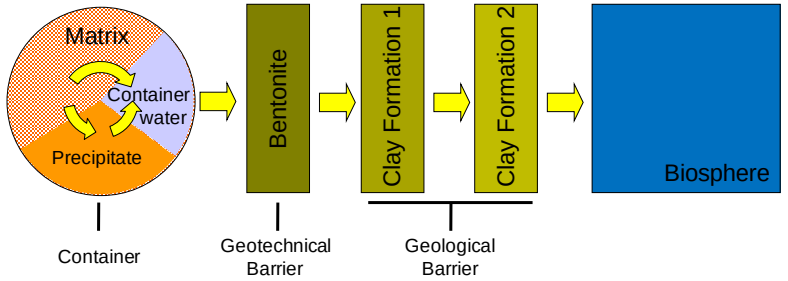
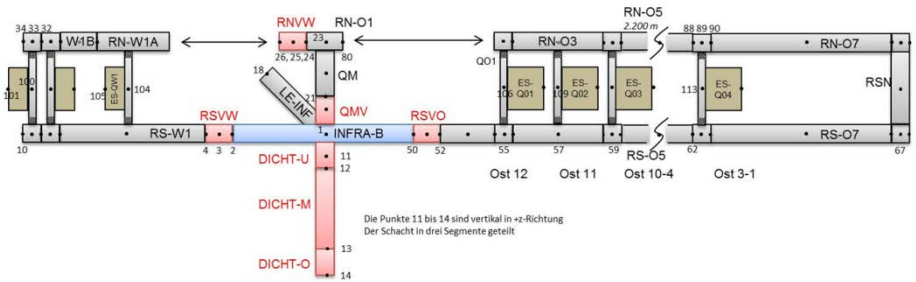
Repository PA models

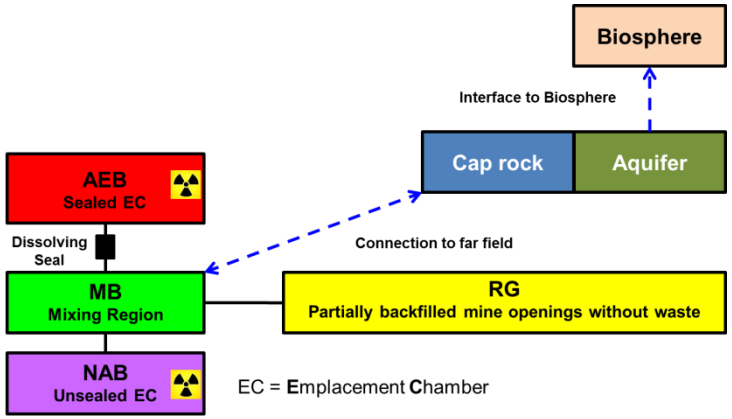
- Repository for SF and HLW in clay
  - diffusive radionuclide transport
  - sorption in clay



- Repository for SF and HLW in rock salt
  - convergence, closure of mine parts
  - advective and diffusive RN transport
  - possibility of zero output

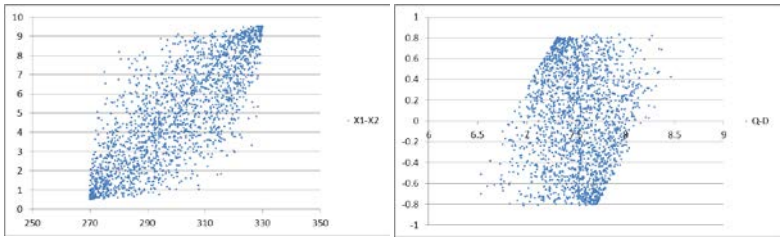


- Repository for LILW in rock salt
  - convergence, gas production
  - dissolving seal: change of model behaviour after failure

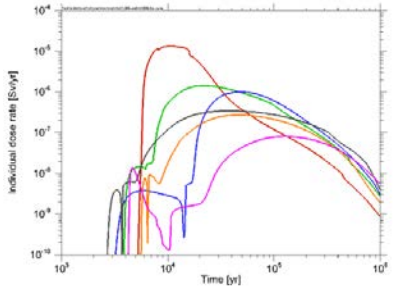


Typical properties of repository PA models

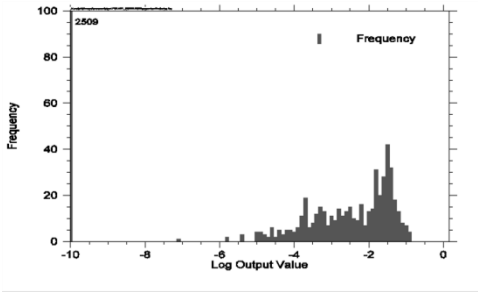
- Parameter dependencies
  - not always describable as correlation



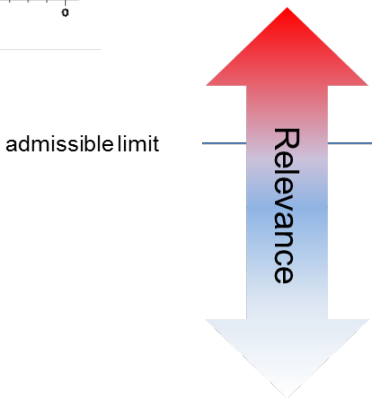
- Highly non-linear model behaviour
  - changing direction of influence of parameters
  - (quasi-)discontinuities



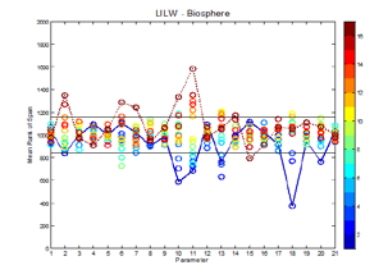
- Wide span of output distribution
  - several orders of magnitude, zero possible
  - non-Gaussian output distribution

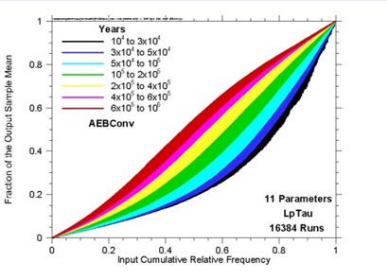


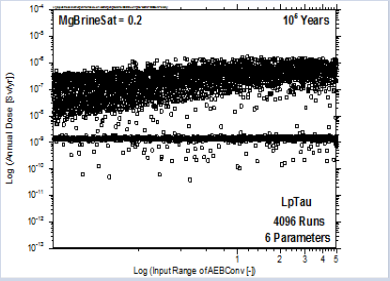
- Different relevance of high and low output values
  - low values are of minor interest
  - high values are relevant for the safety assessment



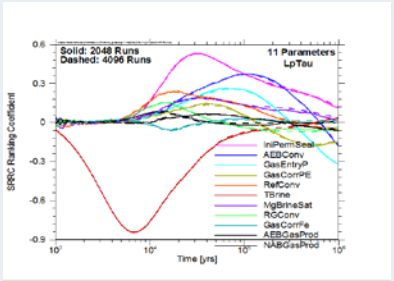
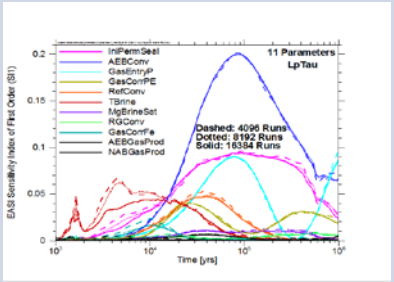
Graphical sensitivity analysis (selected methods)

Method	Advantages	Disadvantages
Mean rank plot 	• All parameters in one figure • Eye-catching prominence of important parameters • Good for first orientation/screening	• Little information about kind of influence • Tends to underestimate non-monotonic influence • Unable to show time development

CSM plot 	• Provides information about direction of influence
	• Can detect non-linear and non-monotonic influence
	• Colour-coding for
	  • time-development
	  • or parameter distinction
		• Tends to look confusing with many parameters in one figure

Scatterplot 	• Reveals complex model behaviour and parameter influences
	• Good to improve model understanding
	• Additional information can be colour-coded:
	  • dominating radionuclide
	  • other parameter value
	  • ?
		• Only one parameter per figure
		• Unable to show time development

Computational sensitivity analysis

Method	Advantages	Disadvantages
Correlation-/regression-based (without rank transformation)	• Easily understandable concept • Computationally cheap • Provides “true” quantitative information about linear influence of parameters • Detects direction of influence	• Assumes linear relationship • Inadequate for models with low R^2 • Can yield misleading results
Correlation-/regression-based (with rank transformation) 	• Better adequate for nonlinear models • Detects direction of influence	• Assumes monotonic relationship • Loss of quantitative meaning due to rank transformation • Inadequate for models with low Rank-R^2 (e.g.: many zero runs)
Variance-based 	• Adequate for all kinds of models • Provides “true” quantitative sensitivity measure • Can provide information about orders of parameter influence (interaction)	• Mathematically demanding concept • Computationally expensive (in general) • Requires high number of model runs • No information about direction of influence

Variance-based sensitivity analysis (selected methods)

Method	Advantages	Disadvantages
Sobol'	• Provides sensitivity indices of any order	• Requires specific sampling • Samples are not extendable • Computationally expensive and time-consuming
FAST/EFAST	• Computationally cheap	• Requires specific sampling • Samples not extendable • No parameter correlations • Poor coverage of parameter space • Provides only first order and total order (EFAST) sensitivity indices • Poor performance on models with discontinuities
SDP	• Allows any sampling scheme • Extendable samples • Seems to provide reliable results	• Complicated theory • Very computationally expensive
EASI	• Allows any sampling scheme • Extendable samples • Seems to provide reliable results • Fast and computationally cheap	• Less accurate for higher-order sensitivity indices

Sampling (selected methods)

Method	Advantages	Disadvantages
(Pseudo-)Random sampling	• (Ideally) statistically independent sample points • Allows proper statistical statements • Best adequate for uncertainty analysis	• Typical clustering leads to inhomogeneous coverage of parameter space • Requires high sample sizes for sensitivity analysis
Stratified sampling Latin Hypercube sampling (LHS)	• More homogeneous coverage of parameter space	• Loss of statistical independence of sample points • Does not seem to be significantly superior to random sampling for computational sensitivity analysis in practice
Quasi-random sampling Low discrepancy sequences (LpTau)	• Optimised for homogeneous coverage of parameter space • Performs significantly better than random sampling/LHS for all kinds of computational sensitivity analysis • stable results with fewer runs	• No (or little) random influence • Inadequate for proper uncertainty analysis

Thank You for Your Attention!