Comparison of Sensitivity Analysis methods applied on a groundwater flow and mass transport model

The case of Andra Meuse/Haute-Marne site

G. Deman, J. Kerrou, H. Benabderrahmane, P. Perrochet

1 CHYN - Centre of Hydrogeology and Geothermics, University of Neuchâtel - Emile-Argand 11, CH-2000 Neuchâtel - Switzerland
2 Andra - Agence Nationale pour la gestion des Déchets Radioactifs - 1/7 rue Jean Monnet, 92298 Châtenay-Malabry - France

correspondence: gregory.deman@unine.ch

FLOW MODEL AND LIFETIME EXPECTANCY CALCULATION

The Model

- Assess Model’s response sensitivity to correlated Hydraulic conductivities (K) and porosities (n) of 14 hydrogeological layers
- Apply multiplicative factors to correlated inputs: sample correlated factors
- Use Gaussian random sampling centred on 1

The Problem

Correlated Radial Sampling (Campolongo et al., 2011)
- Domain of existence
- Between Layers

Correlated Latin Hypercube Design (Iman & Conover, 1982)
- Latin Hypercube Samples
- Aggregate samples
- Between Layers

Experimental Designs

Sensitivity Analysis

Elementary Effects Methodology (Morris, 1991)
- Purely negative effect of \( K_j \) with little interaction and/or order effect
- Purely positive effect of \( n_j \) with strong interactions and/or order effect leading to wide spreading of response value
- Slight purely negative effect of \( K_j, K_j \) and \( K_j \), \( j = 1, ..., 14 \)

Kendall Rank Correlation Coefficient
- Strong negative effect of \( K_j \) and \( n_j \)
- Slight positive effect of \( n_j \)
- Slight negative effect of \( K_j, K_j, n_j, n_j, n_j, n_j, n_j, n_j \), \( j = 1, ..., 14 \)

Polynomial Regression + Student t-test
- Negative set order effect of \( K_j, K_j, K_j, K_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, \) and \( n_j \)
- Positive set order effect of \( K_j, K_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, n_j, \) and \( n_j \)
- Many two-ways interactions

Discussion

Correlated sampling techniques avoid unrealistic parameter combinations that could possibly give misleading Sensitivity Analysis results.

Methods

Elementary Effects Methodology (Morris, 1991)
- Gives valuable qualitative assessment of the sensitivity of the response to model parameters
- Allows the selection of a subset of important parameters
- Does not allow the selection of a subset of non-important parameters

Kendall RRC
- Allows the detection of high-order and interaction effects
- Allows the selection of a subset of non-important parameters
- Uses an approximation of the true response

Polynomial Regression + Student t-test
- Allows the selection of a subset of non-important parameters
- Does not allow the selection of a subset of important parameters

Results

Layer: Mid-upper Bathonian
- Strongly reduces the transit time of solute throughout the model because of its high Hydraulic conductivity (Km)
- Layers: Lower Bathonian (Km), Dalle Nacrée (Km) and Sequanian (Km)
- Rauisuchian (Km) and Sequanian (Km) also reduce the Lifetime Expectancy to a lesser degree because of their high Hydraulic conductivities
- Porosities have little direct effects on the response, except for layer: Marne de Longeay (n) where strong interactions or high-order effects take place