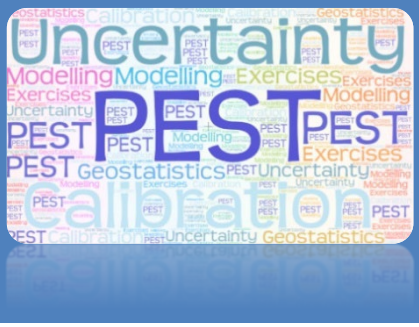

Groundwater Numerical Models and How to Make them Useful

Recorded lessons

Programme

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Groundwater Numerical Modelling

Session A - Review of key topics
Fundamental concepts of groundwater flow: flow equations, aquifer properties, warnings

Session B - Geostatistical data processing
Introduction to applied geostatistics
Exercise
Application of basic geostatistical tools to a contaminated site. Analysis and processing of hydrogeological datasets, semivariogram modelling, field data regionalization, uncertainty of spatial distributions.

Session C - Numerical Modeling
Introduction to numerical modeling in groundwater: solution of flow equation through finite differences and finite elements, grid and mesh construction, boundary conditions, model assumptions and limits
Exercise
Creation of a simple numerical model with MODFLOW: setting of the grid, boundary conditions, properties, observation points

Sensitivity analysis and calibration of parameters in the previously created model.

Session D -Introduction to PEST
What is calibration? Review of Vectors and Stats.

Part 2 - Groundwater Model Calibration

Session A - Getting familiar with the command line
Windows settings to make things easier
Exercise
Execution of general tasks through the prompt line.

Session B - Structure of files
- Modflow input/output files
- PEST input/output files

Session C - Traditional Parameter Estimation
- Well-posed inverse problem
- Manual regularization

Session D - Highly parameterized inversion
- Subspace regularization – singular value decomposition
- Tikhonov regularization
- Pilot points as a spatial parameterization device

Exercise
Pilot point calibration of parameters applied to a pre-built model. Critical evaluation of results

Part 3 - Making the modelling appropriate for the problem: How and Why

Session A - Uncertainty analysis
- Bayes equation
- Worst case analysis
- Using geostatistics for prior uncertainty analysis
- Rejection Sampling
- Markov chain Monte Carlo
- Linear uncertainty analysis

Exercise
Hands-on exercise on uncertainty analysis applied to a pre-calibrated model

Session B - Model appropriateness
- Null space Monte Carlo
- Ensemble smoother
- Direct predictive hypothesis testing
- Data space inversion

Exercise
Continuation of the exercise on uncertainty analysis

Session C - Decisions and Modelling
- Dealing with model defects
- Formulation of an appropriate objective function
- The role of model validation
- Metrics through which decision-support modelling should be judged
- When to calibrate and when not to calibrate

Session D - An overview of model-partner software provided through the PEST and PEST++ suites
- Optimization
- Optimization under uncertainty
- Review of optimal PEST settings