



Online Course Groundwater Numerical Models and How to Make them Useful

Recorded lessons

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Course Overview

The course covers a wide range of topics, from GIS data processing to the most advanced calibration and uncertainty analysis techniques through **PEST** and **PEST++** suites. The course targets those who develop, calibrate, deploy and rely on models to support environmental decision-making as well as water resources managers, stakeholders and anyone who wishes to better understand what groundwater modelling can, and cannot, offer to the decision-making process.

The **first part** deals with data processing, geostatistics and the basics of modelling, introducing the first concepts of automated model calibration through PEST.

The **second part** focuses on model calibration. This will be undertaken by using both PEST and the new ensemble smoother available through the PEST++ suite. These programs will be used from both the command line and from the *Groundwater Vistas* Graphical User Interface. The basic instructions will be provided on command line use. PEST support utilities will be also demonstrated.

The **third part** focuses on uncertainty analysis and on its application to decision-support modelling; dedicated software from the PEST and PEST++ suites will be explained and used in real-world exercises.

Course access

- 4 months from the first access

What's included

- 2 months of *Groundwater Vistas* Licence
- Q&A individual live sessions or request
- 20% discount on the everlasting GWV license

Language

- English

Registration & fees

- 500 €
- 250 € Students

Course Programme

Part 1 - 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