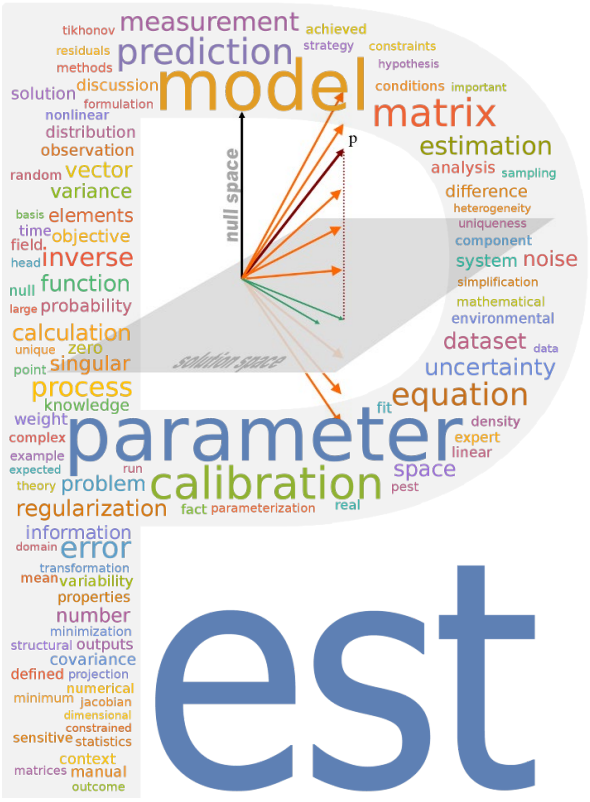
School of hydrogeological Modelling & Project-related strategies

the PEST course
Application & Theory
On-site/Online Course 2024
September 17th-20th, Italy

UNDER THE AUSPICE OF Italian Chapter

Ente di Formazione Accreditato



Course overview

This short course is intended to help those who use a graphical user interface (GUI) for model setup to gain familiarity with some of the principles and practicalities of calibration and uncertainty analysis. It is designed to help you get the most out of this interface when using **PEST**/**PEST++**. The course also shows how a modeler can gain access to extra inversion and uncertainty analysis functionality by going beyond the interface when required. Finally, it provides an overview of new *data assimilation* and *uncertainty analysis* technologies that will have a profound effect on the way in which decision-support modelling is undertaken, but that are actually quite easy to implement.

Pre-course online session is dedicated to introducing the course, getting to know each-other, and solve any software installation issues.

Day 1 deals with preliminary data processing, and the basics of modelling with MODFLOW 6, introducing the free Graphical User Interface ModelMuse with simple exercises.

Day 2 and 3 focus on model calibration and linear/nonlinear sensitivity/uncertainty analysis using PEST and the PESTPP-IES ensemble smoother. We will access this functionality from the GUI, and then show you how to access it from the command line. Usage options and theory will be explained.

Day 4 is a little different. We present a simple explanation of some new technologies – most of them ensemble-based in one way or another. These are actually relatively easy to use, if you are prepared to go beyond the GUI. On day 4, we also invite you to talk about your own site problems, and how to decompose these problems so that they can be easily addressed through modelling. (Problem decomposition is the key to successful modelling.)

Post-course online session: doubts and questions are more likely to arise *after* rather than *during* the course. The session discusses doubts and issues that have "matured" through the "try-it-yourself" process.

PEST
Model Independent Parameter Estimation & Uncertainty Analysis

PEST, PEST_HP & PEST++ Users
Public group

Connect with us on LinkedIn

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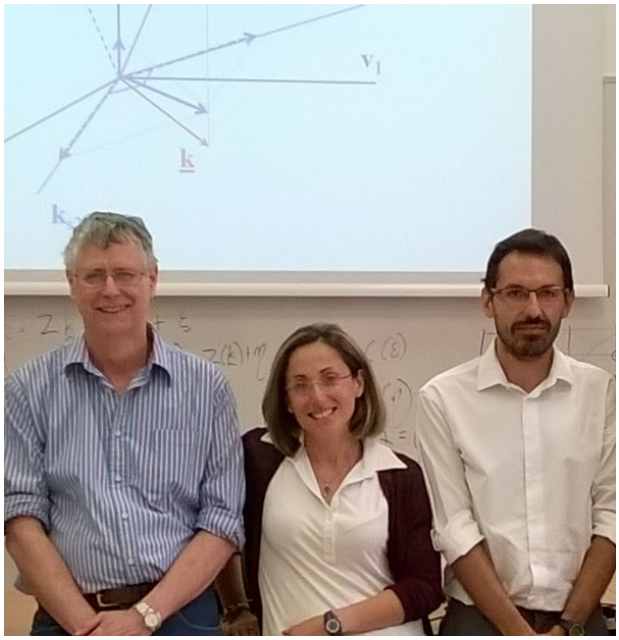
Trainers



John Doherty, Ph.D, **is the author of PEST** and its supporting utility software suites. He is a self-employed consultant, who also holds a university position where he undertakes research and supervises PhD students. John also leads the GMDSI initiative, a university-hosted, industry-funded body that assists in development of simulator-support software and training in the principles and practices of decision-support modelling. Since January 2021 he is part of the Scientific Committee of SYMPLE.

Francesca Lotti, Ph.D, is a consultant hydrogeologist and partner at Kataclima srl Società Benefit. In 2021 she started SYMPLE, an Innovative Start-Up. She has nearly 20 years of experience in field investigations and numerical modeling with MODFLOW and FEFLOW of contaminated sites, mines, geothermal plants, coastal aquifers, dewatering projects and more. She collaborates with national and international research institutions and companies.

Giovanni Formentin is an environmental engineer graduated at Politecnico di Milano. He is a founding partner of Tethys srl, which is a consultancy firm specialized in hydrogeology, and he is president of IT2E srl, an isotope laboratory providing services to the environmental and oil&gas sectors. He has been working since 2002 as a consultant and researcher in the fields of hydrogeology and water management. In particular, he applies flow and transport models to the management of water resources and contaminated sites, aimed at qualitative and quantitative characterization, planning of remediation, and saltwater intrusion. With regard to contaminated sites, it has carried out activities and built models for the main Italian petrochemical sites and refineries. He has also carried out water management studies and numerical models on regional aquifers, in Italy and abroad, including the Bekaa valley in Lebanon and the Central Dry Zone in Myanmar. Other studies were aimed at stochastic forecasting of the effect generated by the interventions on aquifer systems, assessing the interaction between groundwater and infrastructures and designing dewatering interventions. Formentin held groundwater modeling courses using MODFLOW and FEFLOW at the Politecnico di Milano and Federico II University of Naples, as well as modeling and uncertainty analysis courses with PEST together with John Doherty and Francesca Lotti. Since January 2021 he is part of the Scientific Committee of SYMPLE.

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Course Programme

September 3 (9 am – 1 pm)
On-line session

- Presentations
- Introduction of the course
- Instructions for installing the software and access the e-learning platform
- A test model is provided to check that everything runs fine
- Suggested readings to "foretaste" PEST
- Assignment: a tutorial is provided that explains how to build a simple model with ModelMuse

September 17 (9 am -1 pm; 2-6 pm)

Introduction to history matching

- Aspirations and metrics for decision-support modelling, and how this type of modelling differs from explanatory modelling.
- The role of simulation-support software in achieving decision-support modelling metrics.
- Overview of MODFLOW 6 and usage of MODFLOW 6 through the ModelMuse graphical user interface.

Workshop 1 - Model building in ModelMuse

September 18 (9 am -1 pm; 2-6 pm)

Model Calibration

- The difference between model calibration and history-matching.
- How regularization achieves uniqueness.
- Short introduction to geostatistics
- The advantages of highly parameterized inversion.
- Tikhonov regularization and singular value decomposition
- Pilot points as a parameterization device.
- Use of PEST in model calibration.

Workshop 2 - MODFLOW 6 settings in ModelMuse. Getting familiar with the command line. Preparing for calibration.

September 19 (9 am -1 pm; 2-6 pm)

Sensitivity and Uncertainty Analysis

- Difference between sensitivity analysis and uncertainty analysis
- Bayes equation
- Linear uncertainty analysis
- Use of PESTPP-IES for nonlinear uncertainty analysis

Workshop 3 - Post-calibration linear analysis.

September 20 (9 am -1 pm; 2-6 pm)

Recapitulation and looking to the future

- More on ensemble methods
- Data space inversion
- Ensemble space inversion
- Principles of optimization (under uncertainty)
- Discussion

Workshop 4 - Nonlinear analysis of predictive uncertainty.

Assignment

An optional exercise will be proposed as homework. This will test assimilation of the course contents, and how to overcome the most common obstacles for beginners. Assistance is provided in case you get totally stuck.

October 10 (9 am -1 pm; 2-6 pm)
On-line session

Practicalities, examples and discussion

- The effect of model defects
- Formulation of an appropriate objective function
- Direct predictive hypothesis testing
- When to be simple and when to be complex
- When to calibrate and when not to calibrate
- Examples
- Getting the most out of PEST and PEST++

Q&A session

The aim of the last session is to evaluate the assignment, to discuss issues encountered, and to answer the questions that have arisen after completing the exercise by yourself.

The course is informal. We have a plan for what we want to cover. However, in times such as these when technology is changing fast, it is easy to feel overwhelmed and confused.
So, some of what we talk about, and how we talk about it, will be governed by you, the audience. Feel free to come along and discuss your problems.
We will do our best to meet you where you are at!

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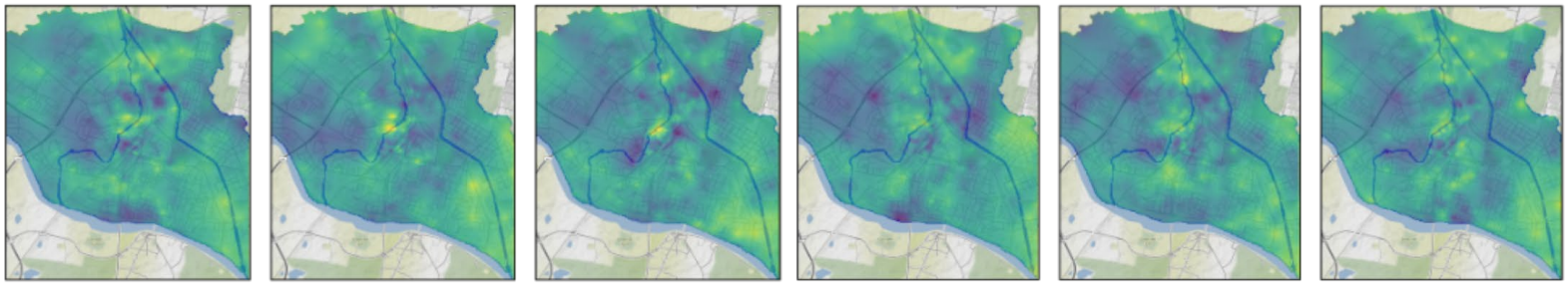

What is included

- Access to live lessons (both in the on-site classroom and remotely)
- Software and installation instructions provided 1 month before the course
- Material to carry out the exercises
- Access to our e-learning platform to watch again the recorded lessons
- *APC credits* for Italian Geologists
- Coffee breaks

Remote/Live Attendance

The course can be attended blended (online and onsite sessions) or completely by remote. Lessons are recorded. The venue is located in Vetralla (VT), Italy (60 km from Rome).

Costs

SYMPLE is an Accredited Training Organization, VAT is not due (art. 10 DPR 633/72).

- Regular: 1000 €
- IAH/SGI: 800 €
- Students/ECHN: 500 €
- Scholarships available for the attendees of the 3rd ed. of the SYMPLE School
- Installments available

We live in a wonderful place, surrounded by wild woods and nearby the volcanic Lake Vico… For accommodation suggestions and "how to get there" advises, just ask us!

Other opportunities to "meet" PEST

- See roadmaps, videos, webinars, tutorials and frequently asked questions that are accessible for free through the PEST web pages.
- Further training material is available on the GMDSI web pages.
- September 2-6, University of Neuchâtel, Switzerland
- November 19-22, Perth, Australia

Registration

Register preferably before August 23rd, 2024

OUR MISSION

SYMPLE is an Innovative Start-up founded in 2021 that intends to **promote and facilitate the understanding, use and evaluation of hydrogeological numerical models through a multidisciplinary program associated with the use of strategies aimed at solving specific problems**.

website @info@hydrosymple.com telegram +39.0761.481622 LinkedIn