



Online: September 8th

Onsite: September 15th - 19th, Italy

Course overview

This five-day course is led by John Doherty, author of PEST. He will be assisted in practical sessions by Francesca Lotti. The course covers the theory behind modern-day inversion and uncertainty analysis as these are applied to groundwater modelling. Just as importantly, practical sessions demonstrate how theory can be turned into workflows using a graphical user interface such as ModelMuse in conjunction with utility software from the PEST suite. This utility software allows a modeler to undertake calibration and uncertainty analysis in innovative ways that are not supported by off-the-shelf modelling interfaces.

On-site/Online Course 2025

the **PEST** course

Application & Theory

Assignment of site-specific parameters to models that must be used to support expensive decisions provides important insights into issues such as appropriate structural and parameterization complexity. A particularly exciting topic is that of non-stationary geostatistics, and how these can be used to parameterize models that possess both structured and unstructured grids.

Data space inversion is another exciting new technology. It enables data assimilation and predictive uncertainty analysis to proceed without the need to actually adjust model parameters. This has profound implications for the speed with which sophisticated numerical models can be built and deployed to support operational and regulatory decision-making.

John Doherty is the author of PEST and PEST-support utility software. Until recently, he also contributed heavily to GMDSI, an industry-sponsored initiative to boost awareness and education on the principles and practice of decision-support groundwater modelling; see https://www.gmdsi.org

Over his career of nearly 50 years, John has worked in the private, public and Tertiary sectors. He has also undertaken extensive research and development in topics related to decision-support modeling.

However John has spent most of his career as a consultant. Through his company (Watermark Numerical Computing), he has assisted colleagues worldwide in building, historymatching and deploying models that address issues such as extraction sustainability, high and low enthalpy geothermal, contaminant remediation, and environmental impacts of mining and coal seam gas extraction.



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Course Programme

September 8 (10 am–1 pm CET)	September 18 (9 am-1 pm; 2-6 pm)
Optional on-line preliminary session	Uncertainty in uncertainty: parameterizing
 Introduction to the course 	the prior
 Instructions for installing the software and 	Data space inversion
accessing the e-learning platform	Ensemble space inversion
 A test model is provided to check that 	Hierarchical inversion
everything runs fine	 How history-matching can do more harm
• What to read to get a "foretaste" of issues	than good
related to model parameterisation	3
Workshop 1: videos and tutorials are provided to	Workshop 4: nonlinear analysis of predictive
build a simple model using ModelMuse	uncertainty.
September 15 (2-6 pm)	September 19 (9 am-1 pm)
Metrics for decision-support modelling	Optimization under uncertainty
• Brief review of linear algebra and geostatistics	Data worth analysis
• What does "calibration" really mean?	Some considerations for contaminant
• Bayes theorem, and how it is applied in	transport modelling
groundwater modelling	Some considerations for low enthalpy
 Predictive uncertainty and predictive error 	geothermal modelling
Old style calibration based on parameter	 "Group therapy": participants discuss their
parsimony: why it doesn't really work	own problems
Workshop 2: MODFLOW 6 and PEST settings in	Assignment
ModelMuse. Preparing for calibration.	An optional exercise will be proposed as homework.
September 16 (9 am-1 pm; 2-6 pm)	This will test assimilation of the course contents, and
 The costs and benefits of parameter 	how to overcome the most common obstacles for
uniqueness	beginners. Assistance is provided in case you get
 Highly parameterized inversion and 	stuck.
regularization	On request
 Subspace methods including singular value 	On-line session
decomposition	Q&A session
Tikhonov regularization	Optionally, an additional on-line session can be
 Pilot points as a parameterization device 	organized to discuss questions and issues that you
 Construction of covariance matrices for 	may have after you have thought about the course
parameter regularization and uncertainty	for a while.
analysis	₩ ½
Workshop 3: model calibration with pilot points.	symple
September 17 (9 am-1 pm; 2-6 pm)	
 Principles of uncertainty analysis 	
 Nonstationary geostatistics 	
 Generating random hydraulic property fields 	
for structured and unstructured grids	
 Linear uncertainty analysis 	
 Ensemble smoothers: theory and practice 	
Diverse and a structure the second structure of	

• Direct predictive hypothesis-testing **Workshop 4** - Post-calibration linear analysis.

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✓ telegram







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What is included

- Access to live lessons (both in the on-site classroom and remotely)
- Software and installation instructions provided before the course
- Material to carry out the exercises
- Access to our <u>e-learning platform</u> to watch again the recorded lessons with no limit of time
- APC credits for Italian Geologists
- Coffee breaks and light lunches.

Remote/Live Attendance

The course can be attended blended (online and onsite sessions) or completely by remote viewing. Lessons are recorded. The venue is located in <u>Vetralla</u> (<u>VT</u>), 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 current edition of the <u>SYMPLE School</u>
- Installments available





Register preferably before July 26, 2025



SYMPLE is an Innovative Start-up founded by Francesca Lotti 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.

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



Other opportunities to "meet" PEST

- See <u>roadmaps</u>, <u>videos</u>, <u>webinars</u>, <u>tutorials</u> and <u>frequently asked questions</u> that are accessible for free through the <u>PEST web</u> <u>pages</u>.
- Further training material is available on the <u>GMDSI</u> web pages.