symple

School of hydrogeological modelling & Project-related strategies

forth edition

Info & Programme

2025 Edition: January 13th – December 31st

Pre-School orientation meeting: December 5th-6th, 2024

On-line (live & recorded lessons)

Early Bird registration expires on July 17th, 2024

Final registration deadline: November 15th, 2024

Rev.0

05/06/2024

Ente di Formazione CONSIGLIO NAZIONALE GEOLOGI Accreditato

The initiative is under the auspice of the

International Association of Hydrogeologists – Italian Chapter

iah aih Italian Chapter

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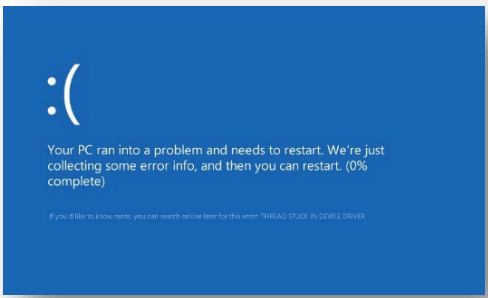
Contents

FOREWORDS

SYMPLE is a school about groundwater modelling that starts from zero. The only prerequisites are the will to learn and a technical-scientific background. The corequisites are those needed to be a numerical modeller: patience, an investigative approach and Information and Communication Technology (ICT) propensity.

If you find yourself getting nervous when your computer crashes… **you might need to work on your digital/computer skills and patience before attending!!**



School Outlook

OUR MISSION

SYMPLE is an Innovative Start-up that intends to **promote and facilitate the understanding, use and evaluation of hydrogeological numerical models through a multidisciplinary programme associated with the use of strategies to solve specific problems**.

SYMPLE aims to impart an emerging paradigm, supported by the latest ideas and cutting-edge software for data assimilation, of "*starting from the problem and working backwards*". This workflow involves the initial step of identifying the data with the highest potential to minimize the uncertainties associated with decision-critical predictions, and then designing a numerical simulation strategy, based on the open-source MODFLOW family of codes, that serves the decision-support imperative of actually quantifying and reducing those uncertainties.

Development of better strategies to address pressing problems requires the same data and software mostly already available (PEST and PEST++ suites) but a new mindset. In many cases, the modelling will be <u>more effective and less expensive</u> because it is:

- management targeted;
- no more complex than it needs to be to serve the decision-support demands;
- supported by project-related strategies with associated specific software.

That is, modelling will be complex enough to assimilate data and reduce uncertainty, but strategically simple because it is decision-focused.

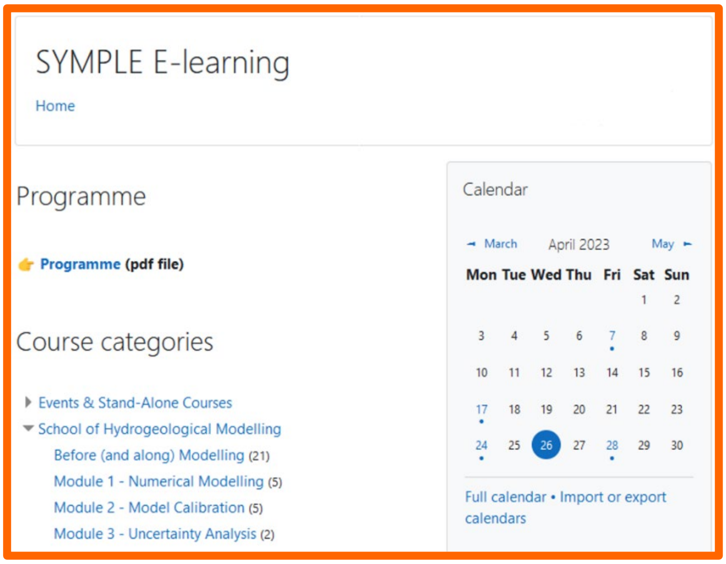
School Outlook

SYMPLE proposes a comprehensive, applied, internet-based School of Hydrogeological Modelling. By undertaking the courses, participants will acquire practical knowledge of effective model deployment in different decision-making contexts.

Differing from other schools, SYMPLE's mission extends beyond "traditional teaching". We aim to enhance individual learning to transfer as much experience as possible to the participants. In short, we want participants to become "expert hydrogeological modellers". For this reason, we have selected a comprehensive set of tools, explained in a modelling-targeted way, and applied to real-world cases that are much more difficult to "solve" than the step-by-step exercises, where everything works fine.

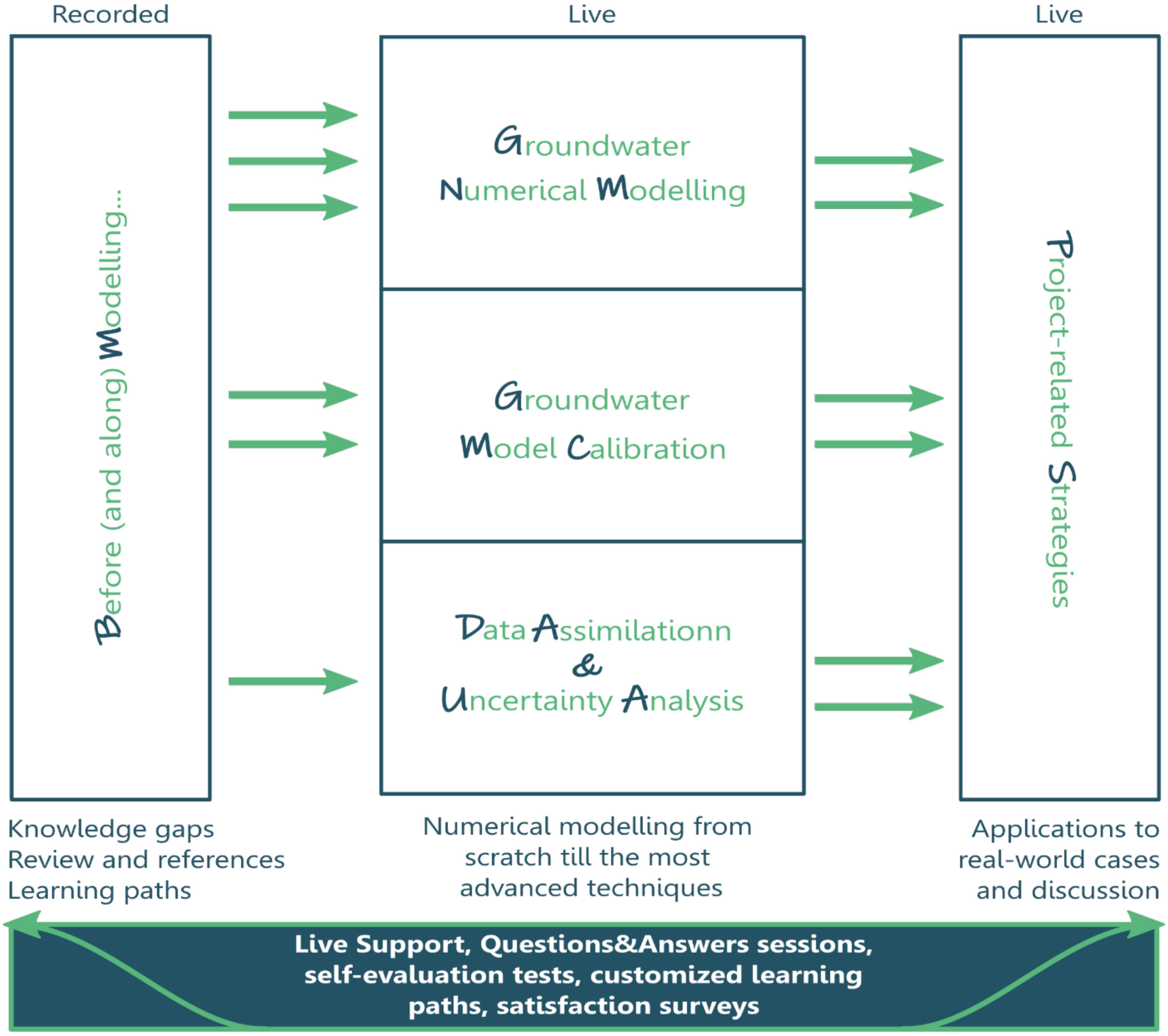
The trainers look at the school attendees not as "students", but as "colleagues" to work and solve problems with. Participants engage directly with the trainers through dedicated Q&A fora and by asking one-on-one discussions. We wholeheartedly promote interaction, as it is a fundamental knowledge-sharing component.

All the lessons are organized in the SYMPLE E-learning platform, based on the open-source Moodle environment.



School Contents

The programme is organized into a *Before (and along) Modelling* section, three *Modelling Modules*, and the Project-related Strategies section, which concludes the School by applying the whole modelling process to a real-world problem.



Live lessons are mostly held by Francesca Lotti, Thomas Reimann and John Doherty, with the participation of other experts according to the subject. All live lessons are held in English, recorded and uploaded on the E-learning platform for later reference.

Most exercises use public-domain software, such as QGIS, Python scripts and the MODFLOW graphical user interface (GUI) ModelMuse. The commercial GUI Groundwater Vistas is also applied since it is the one that better supports the automatic calibration process through PEST. Participants can purchase the licences with 20% discount, as agreed with the software developers.

Before (and along) Modelling...

The first part of the School is a kind of "modeller's toolbox" that, in association with textbooks and papers, is intended to provide the necessary "bricks" needed to approach hydrogeological problems. The flipped classrooms approach allows the students to watch the recorded lectures and collaborate in online discussions with the trainer's guidance on request. The importance of getting back to the pillars of geology, hydrogeology, physics, and maths is surely clear, nevertheless it will become clearer during the subsequent modules. Even if placed "before modelling", this section will be a companion along the whole School: thanks to learning objectives and pre-assessment, learners can be directly pointed back to the required courses to improve their understanding. Attendance of the courses is up to the individual, with our assistance to create a learning path, according to his / her own interests and personal background.

Two preliminary meetings are organized at the beginning of December to introduce the School and provide orientation. Two equivalent meetings are proposed in different hours to allow a wider participation according to different time zones of participants from all over the world.

Pre-School Orientation Meetings		CET	Day
Introduction & Overview *F. Lotti, T. Reimann*	**Live session Group 1** **Live session Group 2**	**10am-1pm** **3-6pm**	**2024-12-05** **2024-12-06**

Recorded Courses, Webinars and Insights		Hours	Trainer	Lang.
Basic Hydrogeology	Introduction to Hydrogeology	2:30	*Dragoni, Ducci*	*ENG/IT*
	Types of Aquifers, Springs and Rivers	11:00	*Petitta, Bonomi, Piscopo*	*IT*
	Properties of soil. Geotechnical Investigations	3:30	*Di Matteo*	*IT*
	Hydrogeological investigations and Isotopes	2:30	*Mastrorillo, Petitta*	*IT*
	Structural Geology	2:00	*Guastaldi*	*IT/ENG*
	Geophysics	3:30	*Menghini*	*IT*
	total	*25:00*		
Basic Contaminant Hydrogeology	Hydrogeochemistry	5:30	*Barbagli*	*IT/ENG*
	Solute transport	3:00	*Borsi*	*IT/ENG*
	Contaminants origin and properties (fate and transport). Sustainable aquifer and groundwater remediation	5:30	*Petrangeli Papini*	*IT*
	Groundwater Monitoring	3:30	*Preziosi*	*IT/ENG*
	Regulatory context in Italy	3:00	*Di Gennaro*	*IT*
	total	*20:30*		
Basic methods	Linear algebra	2:30	*De Filippis*	*IT/ENG*
	Statistics and Geostatistics	16:00	*Guastaldi*	*IT/ENG*
	GIS	6:00	*De Filippis*	*IT/ENG*
	Relational databases	6:00	*Barbagli*	*IT/ENG*
	Time series analysis and examples of statistical application	3:00	*Borsi, Meggiorin*	*ENG*
	total	*33:30*		
Groundwater Engineering	Wells construction and Aquifer tests	4:30	*Piscopo*	*IT*
	Groundwater control for construction	1:00	*Preene*	*ENG*
	Roads, Tunnels and Dams	2:30	*Francani*	*IT*
	total	*8:00*		

Before (and along) Modelling...

Recorded Courses, Webinars and Insights		Hours	Trainer	Lang.
Groundwater resources management	Groundwater use in river basin management	1:00	*Rossetto*	*ENG*
	Rural water management	1:00	*Rossetto*	*ENG*
	Measures for adapting to climate change: MAR	4:00	*Rossetto*	*ENG*
	Potable water supply	1:30	*Vettorello*	*ENG*
	Environmental Economics and EU Regulation	3:00	*Leggio, Sapiano*	*IT/ENG*
	Italian regulation on mineral waters production. The case of a mineralized aquifer	2:00	*Viaroli*	*IT*
	Low-enthalpy geothermal plants (open loop)	1:30	*Vettorello*	*ENG*
	Socio-Hydrogeology	3:00	*Re*	*ENG*
	total	*17:00*		
Coastal hydrogeology **Detailed Programme**	Coastal groundwater systems Groundwater flow in coastal aquifers Groundwater exploration in coastal regions Hydrochemistry, Modelling and Management issues	6:00	*Post*	*ENG*
	total	*6:00*		
Python basics	Intro to Python as programming language Fundamentals and advanced features Example applications like analysis of a pumping test and quantification of evapotranspiration Using Python / Pandas to manage hydrological timeseries	4:30	*Borsi et al.*	*ENG*
	total	*4:30*		
Individual talks and assistance	**Live sessions on request**		*Trainers of specific courses*	*ENG/IT/DE*

As the importance of groundwater is growing in awareness, high-quality open-source training materials, software, and tools are becoming available. SYMPLE treasures these resources, integrating them into the training activities and as more in-depth material that can be consulted at any time.

Module 1
Groundwater Numerical Modelling

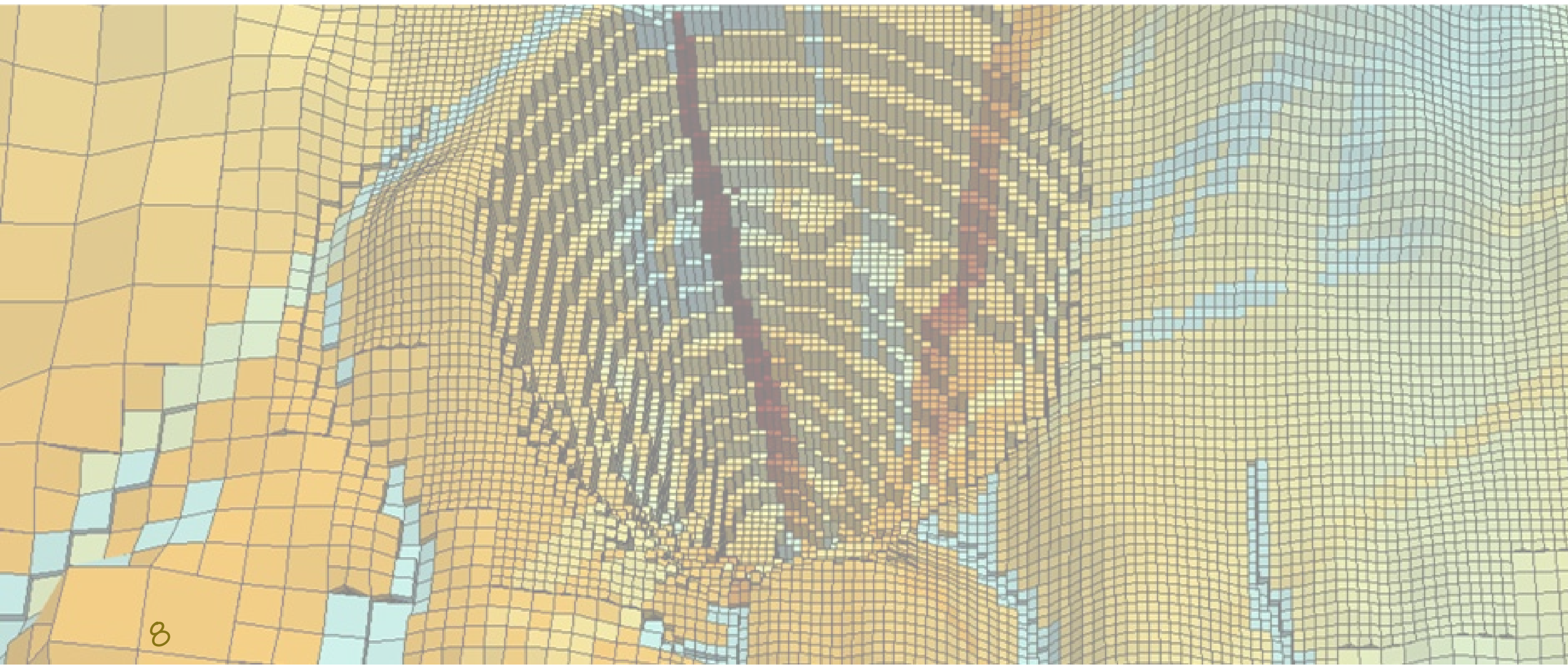
The hydrogeology basics are applied to synthetic and real-world cases to extract salient information from data, to be transferred to the modelling process. The basics of numerical flow and transport modelling is introduced through the GUIs ModelMuse and Groundwater Vistas. Model building is also approached through Python scripting with FloPy.

Live Sessions	Contents	CET	Days
M1-A Review of key topics and assessment of users knowledge *T. Reimann, F. Lotti*	Fundamental concepts of groundwater flow: flow equations, aquifer properties, water balance, and transport equations. Introduction to Python.	3-6pm 10am-1pm 3-6pm	2025-01-13 2025-01-17 2025-01-24
M1-B Data processing *F. Lotti, T. Reimann*	Introduction to applied statistics and geostatistics. Case Study introduction. Analysis and processing of hydrogeological datasets, semivariogram modelling, field data regionalization, uncertainty of spatial distributions. Aquifers and Wells. Flow to wells, capture zone, aquifer investigation and pumping tests evaluation.	10am-1pm 3-6pm 10am-1pm 3-6pm 10am-1pm	2025-01-31 2025-02-07 2025-02-14 2025-02-21 2025-02-28
M1-C Numerical Modelling of flow with MOD-FLOW *T. Reimann, F. Lotti*	Analytical and numerical methods in groundwater: solution of flow equation through finite differences and finite elements, numerical methods, grid and mesh construction, boundary conditions, model assumptions.	3-6pm 10am-1pm 3-6pm 10am-1pm	2025-03-07 2025-03-14 2025-03-21 2025-03-28
M1-D Numerical Modelling of basic transport *T. Reimann, F. Lotti*	Euler / Lagrange approaches, Numerical schemes (FD, TVD, MOC, MMOC, HMOC) and different applications. Uncertainty due to solution method and parameters. Exercise/tutorials with MODELMUSE.	3-6pm 10am-1pm	2025-04-04 2025-04-11
M1-E Model building of the Case Study *F. Lotti, T. Reimann*	Demonstration of model design. Exercise/tutorials with MODELMUSE. Case Study model building, evaluation of aquifer geometry, properties and boundary conditions from previously processed data (M1-B).	3-6pm 10am-1pm	2025-04-16 2025-04-25
M1-F MODFLOW Conduit Flow Process (CFP) *T. Reimann, S. Birk*	The conceptual and numerical model for karst. Theory and application of MODFLOW-CFP, set up with ModelMuse and text editor. Advanced features in CFPv2. Primer and outlook of CFPy (Scripting CFP with Python). Primer and outlook to transport computation.	9am-2pm 2-6pm	2025-05 2025-05

Module 1
Groundwater Numerical Modelling

Self-paced lessons are suggested to integrate the live sessions. The recordings cover alternative approaches to ModelMuse, such as Groundwater Vistas as a GUI for MODFLOW and related programs.

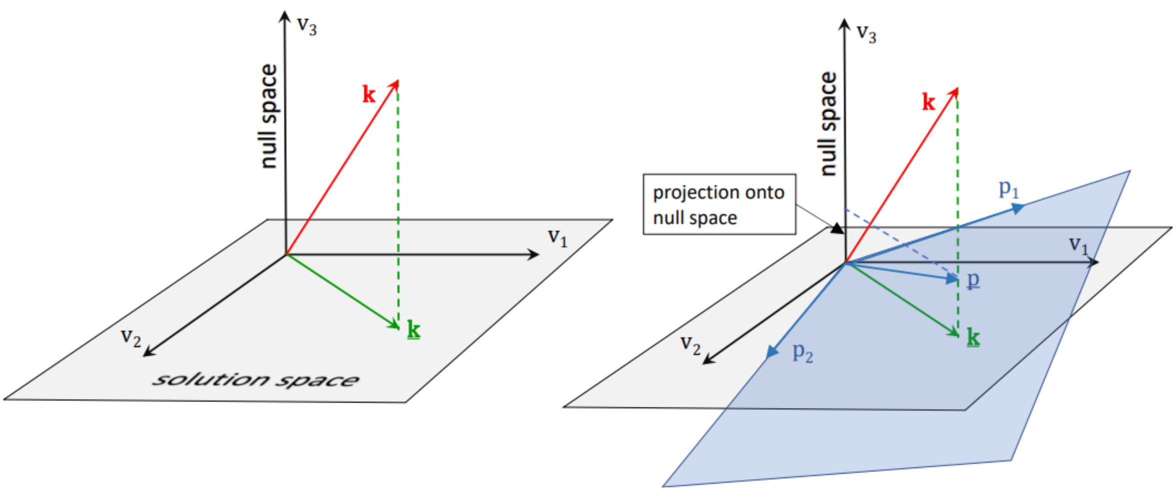
Recorded Lessons	Contents	Hours	Trainer
R1-A Webinar	Getting started in applied groundwater flow modelling. Ten common mistakes in groundwater numerical modelling.	2:00	*R. Hunt*
R1-B Numerical Modelling of flow with MODFLOW in GW Vistas	MODFLOW history. Introduction to GW Vistas. MODFLOW-NWT. Multi-Node Well (MNW) package. Exchanges between surface water and groundwater. MODPATH-5 and MODPATH-7. MODFLOW-6: new strategies.	10:00	*D. Feinstein*
R1-C Transport Modelling with GW Vistas	Contaminant transport with MT3DMS and MT3D-USGS. SEAWAT: introduction to modelling of saltwater intrusion. SEAWAT2005: Heat transport.	10:00	*D. Feinstein*
R1-D Model building with FloPy	Before getting started. A first simple steady state and transient model. Flow and transport model building and predictive use.	5:30	*R. Hugman*



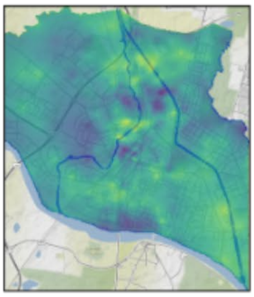
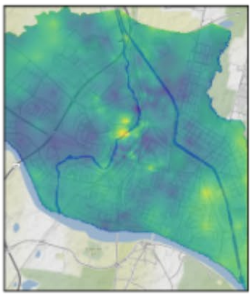
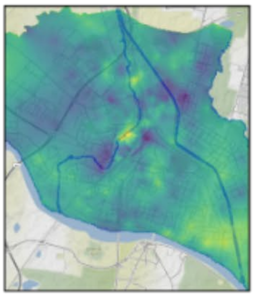
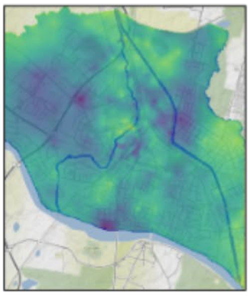
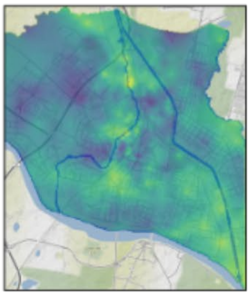
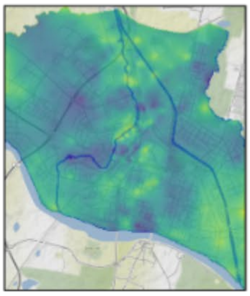
Module 2
Groundwater Model Calibration

The focus of the second module is model calibration. The MODFLOW GUI used in the exercises is ModelMuse in association with PEST(++). John Doherty, the author of PEST, introduces the theory behind history matching ("calibration").

Live Session	Contents	CET	Day
M2-A Introduction to history matching *J. Doherty* *F. Lotti*	An overview of decision-support modelling and its relationship to the scientific method. The null space and nonuniqueness. History-matching: Calibration. The role of data assimilation software such as PEST and PEST++. Exercise - PEST settings in ModelMuse for a synthetic model and the Case Study.	3-6pm 10am-1pm 3-6pm	2025-04-30 2025-05-07 2025-05-14
M2-B Manual regularization *J. Doherty* *F. Lotti*	Traditional parameter estimation: the quest for uniqueness. Manual regularization: theory and practice. Problems with manual regularisation. Exercise – Traditional parameter estimation and critical evaluation of results, for a synthetic model and the Case Study.	10am-1pm 3-6pm	2025-05-21 2025-05-28
M2-C Highly parametrized approach *J. Doherty* *F. Lotti*	Highly parametrized approach: the need for many parameters. Subspace regularization – singular value decomposition. Tikhonov regularization. Pilot points as a spatial parameterization device. Exercise - Pilot point calibration of parameters and critical evaluation of results. Continuation of the Case Study analysis.	10am-1pm 3-6pm	2025-06-04 2025-06-18



Module 3
Uncertainty Analysis

The module is fully dedicated to uncertainty analysis through the use of the PEST suite, explained by the author of the code, John Doherty. A wide set of exercises helps understand complex concepts, using both GUIs and command line inputs. Examples are analyzed to demonstrate data assimilation, uncertainty analysis and its application to decision-support modelling.

Live Sessions	Contents	CET	Day
M3-A Uncertainty Analysis *J. Doherty*	Bayes equation Short discussion on geostatistics Linear uncertainty analysis • Parameter contributions to predictive uncertainty • Optimization of data acquisition • Other uses of linear analysis Principles of nonlinear uncertainty analysis Rejection sampling Null space Monte Carlo Ensemble methods (PESTPP-IES) Data space inversion *Exercises from the command line*	10am-1pm 10am-1pm	2025-06-25 2025-07-02
Practicalities and examples	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 Getting the most out of PEST and PEST++	10am-1pm	2025-07-09
M3-B Exercises *F. Lotti* *G. Formentin*	Exercises about the application of Uncertainty Analysis to the Case Study. Assignment of a real project to develop starting from raw field data, deliver and discuss along the last School section (Project-related Strategies).	3-6pm 10am-1pm	2025-07-11 2025-07-18

Recorded Lessons	Contents	Hours	Trainer
R3-A Advanced modelling with FloPy and Py-EMU	Overview of the *modflow-setup* tool Pre-processing of data and building the model from YML notebook Introduction to PEST++ and PyEMU Set up and run PESTPP-IES	5:30	*M. Fienen* *J. White*

Project-related Strategies

(current state from Sept. 2023, possibly subject to additions)

The aim of the Project-related Strategies session is to harvest information from data so that better decisions can be made, considering a specific problem. This requires that model design reflects not just its hydrogeological context but also its data and management contexts. It requires that models only be as complex as they need to be and that they are dedicated to the quantification and reduction of prediction uncertainties that matter to decisions.

The scientific background of the operational project-related strategies is provided by the concept of "problem decomposition", described in Doherty & Moore, 2023. The term "problem decomposition" characterises an approach to environmental management that renders it amenable to the type of quantitative assistance that numerical modelling can provide. It requires that modelling goals be carefully defined, and that modelling workflows be then designed to serve these goals. As the term "decomposition" implies, it often involves the development of a number of conceptual simplifications, which may invoke concepts such as "impact pathways". These provide a focus for model-based processing of environmental data in ways that improve the likelihood of a management decision being "good" according to the values that system management serves.

Live Sessions	Contents	CET	Day
PS-A Participant Engagement *F. Lotti, J. Doherty, T. Reimann, G. Formentin, A. Pryet*	Description of the problem, datasets and management context Discussion about the assignment results by different groups of participants Alternative approaches Thoughts and individuation of relevant actions to solve the problem.	10am-1pm 10am-1pm	2025-09-10 2025-09-24
	Participants case studies: **if you are building a groundwater model to help you make an important decision, you can submit your case to be analyzed together.**		*Time and number of meetings to be agreed*
PS-B School Conclusions	Concluding meeting with special focus on participants suggestions and "passing of the baton" to the participants of the 2026 School edition.		2025-12-06

Trainers

The Teaching Staff includes about 40 prestigious experts from Universities, Companies, Professional Orders, Public Agencies from different countries.

	Alessio Barbagli *GEOexplorer S.r.l.*	**Gabriele Bernagozzi** *Geologist*	**Steffen Birk** *University of Graz, Austria*	**Tullia Bonomi** *University Milano Bicocca*
	Iacopo Borsi *TEA Sistemi SPA*	**Giovanna De Filippis** *AECOM URS Italia S.p.A.*	**Antonio Di Gennaro** *Engineer - Ministry of the Environment*	**Lucio Di Matteo** *University of Perugia*
John Doherty *Watermark Numerical Computing, Australia*	**Walter Dragoni** *University of Perugia*	**Daniela Ducci** *University of Naples Federico II*	**Marco Falconi** *ISPRA*	**Daniel Feinstein** *Wisconsin University Milwaukee, USA*
Michael Fienen *USGS, USA*	**Giovanni Formentin** *HPC Italy srl SYMPLE*	**Vincenzo Francani** *Politecnico di Milano*	**Enrico Guastaldi** *GEOexplorer S.r.l.*	**Rui Hugman** *INTERA, USA*
Randall Hunt *USGS, USA*	**Luigi Lana** *Kataclima S.r.l., SYMPLE*	**Sara Leggio** *Economist, SYMPLE*	**Francesca Lotti** *SYMPLE*	**Lucia Mastrorillo** *University of Roma Tre*
Mara Meggiorin *Ramboll Italy Srl*	**Antonio Menghini** *Emergo*	**Marco Petitta** *University Sapienza*	**Marco Petrangeli Papini** *University Sapienza*	**Vincenzo Piscopo** *University of Tuscia*
Vincent Post *EDINSI Groundwater*	**Martin Preene** *Preene Groundwater Consulting, UK*	**Elisabetta Preziosi** *CNR-IRSA*	**Viviana Re** *University of Pisa*	**Rudy Rossetto** *Scuola Superiore S. Anna*
Thomas Reimann *Technische Universität Dresden, Germany*	**Manuel Sapiano** *EWA, Malta*	**Luca Vettorello** *Sinergeo S.r.l.*	**Stefano Viaroli** *University of Roma Tre*	**Jeremy White** *INTERA, USA*

Registration

Ente di Formazione CONSIGLIO NAZIONALE GEOLOGI Accreditato	**Prices**	Siamo presenti sul MEPA acquistinretepa	CARTA del DOCENTE SPENDI QUI IL TUO BUONO
Professional credits (**50 APC**) for Italian Geologists	Students - ECHN **1600 €**	SGI – IAH members **2500 €**	Regular **2700 €**
	Registration form	**Payment information**	**Contact us**

To be eligible for a **Scholarship place**, applicants must:

- be resident in and national of low- and middle-income countries (see the list in the application form);
- be preferably 35 years old or younger.

To apply, **fill this FORM** with required information.