sYmple

School of hydrogeological modelling & Project-related strategies

Info & Programme

2026 Edition: January 9th – December 31st

Online courses (live and recorded lessons)

with **unlimited access** to the e-learning platform

Early Bird registration expires on July 17th, 2025

Final registration deadline: November 15th, 2025

DRAFT

15/05/2025

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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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 more effective and less expensive 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.

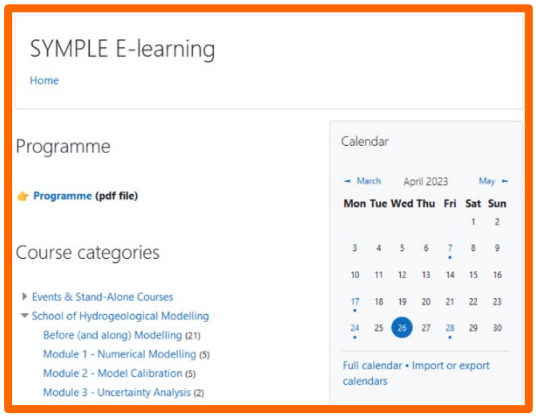
School Outlook

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 chats 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. Part of the training material dealing with the basics of hydrogeology can be freely accessed via the **SYMPLE2025 App** developed by Thomas Reimann in the framework of the EU cooperation project iNUX, funded by the ERASMUS+ program of the European Union.

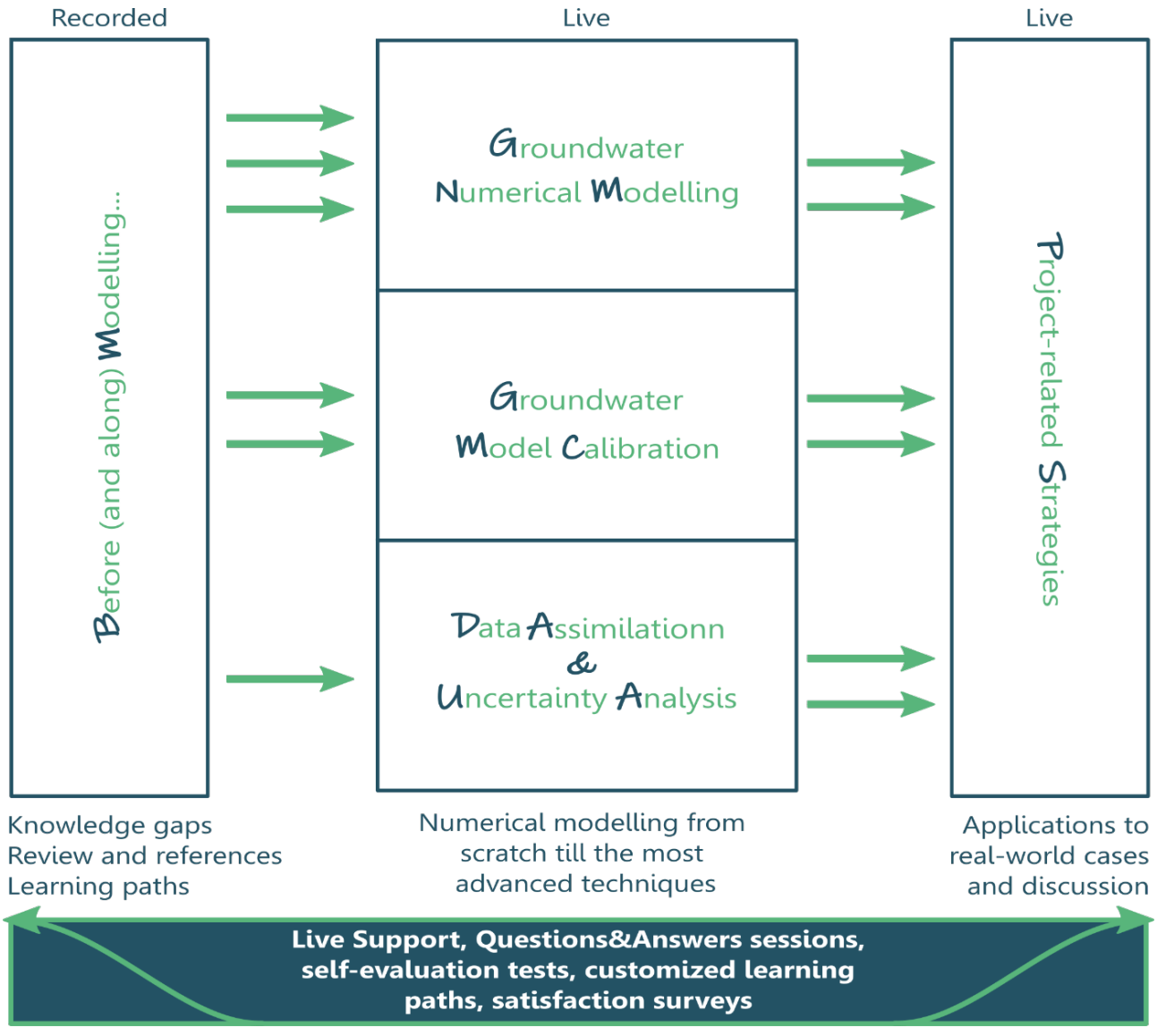


School Contents

The programme is organized into three Live Modules, optional Recorded Courses, a Field Hydrogeology course and the Project-related Strategies meetings, which conclude the School by applying the whole modelling process to real-world problems presented by the attendees.

Live lessons are mostly held by Francesca Lotti, Thomas Reimann, Daniel Feinstein 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 **never-ending access**.

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 (recorded)

The School offers a kind of "modeller's toolbox" that is intended to provide the necessary "bricks" needed to approach hydrogeological problems. The importance of getting back to the pillars of geology, hydrogeology, physics, and maths is surely clear, nevertheless it will become clearer during the School. This section includes hundreds of hours of recorded courses: thanks to self-assessment tests, attendees of the School will be able to detect their main gaps and get back to the pertinent courses. Whether or not to take advantage of this opportunity is up to each participant, according to his/her own interests and personal background.

Preliminary programme

Module 1 – Groundwater Numerical Modelling (live)

The module begins with a review of key topics such as groundwater flow equations, aquifer properties, boundary conditions and transport dynamics. Participants then move into data processing, where they are introduced to geostatistics and hydrogeological data analysis, especially pumping tests interpretation. The module continues with sessions on hydrogeological modelling of flow and transport, covering analytical and numerical methods. Real-world data coming from a landfill site are then used to build a numerical model using MODELMUSE. The Landfill numerical model will be at the basis of the calibration exercises in Module 2.

The first module includes related stand-alone courses that complement the topic of the Module and offer different points of view from international experts.

Preliminary programme

Module 2 – Basic Groundwater Model Calibration (live)

The module introduces the basic concepts of model calibration with the **PEST** suite. Live sessions adopt a "learning by doing" approach, focusing on hands-on workshops. Theoretical concepts are presented in a simplified manner, aiming to provide a comprehensive overview of parameter estimation and data assimilation techniques. Most of the practical exercises are carried out using the graphical user interface (GUI) ModelMuse to support learning.

Preliminary programme

Module 3 – Parameter estimation and uncertainty analysis using PEST/PEST++ (live)

The module deepens 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.

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 new technology explained in the module. 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.

The module will also be offered as a blended stand-alone course, delivered in person in Vetralla.

Preliminary programme

Field Hydrogeology Week (on-site)

Hydrogeological field methods are essential in the training of hydrogeologists and modellers. As demonstrated in the previous modules, groundwater projects rely on data and appreciating how they are collected is an imperative. The present course aims at transmitting the critical thinking necessary to recognize the uncertainties and pitfalls hidden in data collection. Each single measurement should be seen in a wider picture, the monitoring strategy should be able to capture the information we need to solve a problem, we should know how the numbers that we collect will constrain a parameter value in a numerical model. And if that number is not properly recorded, the "information flow" is distorted generating incongruencies, making useless (in the best case, misleading in the worst case) all the subsequent modelling efforts and the final model prediction. The investigation site is a landfill located at NW of Viterbo.

Those who won't be able to attend on-site will be in charge of processing the field data collected by the other attendees which will be on-site.

Preliminary programme

Project related strategies (live on request)

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. These concepts and approaches were the driving motive behind the existence of SYMPLE.

A unique feature of the session is the inclusion of participant case studies through a series of interactive live sessions organized on request. Participants would engage describing their hydrogeological problems, relevant datasets, and the broader management context. Discussion with key experts would explore alternative approaches, assist in identifying key actions to address the problem.

Live schedule and programmes

Pre-School Orientation Meetings		CET	Day
Introduction &	**Live session Group 1**	**10am-1pm**	**2026-01-09**
Overview	**Live session Group 2**	**3-6pm**	**2026-01-09**
F. Lotti, T. Reimann			

Module 1 (T. Reimann, F. Lotti) – 45 h

Live Sessions	Contents	CET/CEST	Days
M1-A Review of key topics	Fundamental concepts of groundwater flow: flow equations, aquifer properties, water balance, and transport equations.	3-6pm 10am-1pm 3-6pm	2026-01-16 2026-01-23 2026-01-30
M1-B Data processing	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	2026-02-06 2026-02-13 2026-02-20 2026-02-27 2026-03-06
M1-C Numerical Modelling of flow with MODFLOW	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	2026-03-13 2026-03-20 2026-03-27
M1-D Numerical Modelling of basic transport	Euler / Lagrange approaches, Numerical schemes (FD, TVD, MOC, MMOC, HMOC) and different applications. Uncertainty due to solution method and parameters. Exercise/tutorials with MODELMUSE.	10am-1pm 3pm-6pm	2026-04-10 2026-04-17
M1-E Model building of the Case Study	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	2026-04-24 2026-04-30

Introduction to applied Groundwater Flow Modelling with Groundwater Vistas (D. Feinstein) – 40 h

The course is also available as a blended stand-alone course.

March 17 (on-line)
3 - 7 pm CET

* *Preliminary checks of computer setup*
* *Introduction to Course*
  a) Objectives and Overview
  b) History of MODFLOW
* *Elements of Flow Modeling*, intro.
  a) Review of quantitative hydrogeology
  b) Governing equation and finite difference
  c) Input parameters

March 18 (on-line)
3 - 7 pm CET

* **Elements of Flow Modeling,** cont.
  d) Boundary conditions
  e) Grid design
  f) Steady-state and transient conditions
* *Basic flow modeling with MODFLOW,* specific input packages and solvers (intro)

March 19 (on-line)
3 - 7 pm CET

* *Basic flow modeling with MODFLOW,* specific input packages and solvers (cont.)
* *Overview of calibration and uncertainty*
* *Example USGS MODFLOW model*

April 07 (blended)
9 am - 1 pm / 2:30 pm - 6:30 pm CET

* *Lab 1*
  - Introduction to Groundwater Vistas Interface
  - Basic MODFLOW model construction – grid design, boundary conditions, and properties
* *Lab 2*
  - Basic MODFLOW model construction – from 2D to 3D and steady state to transient
  - Class demonstration of finite difference method

April 08 (blended)
9 am - 1 pm / 2:30 pm - 6:30 pm CET

* *Lab 3*
  - Particle Tracking with MODPATH
* *Lab 4 and Lab 5*
  - Groundwater/Surface Water Interactions using Advanced Packages (STR, LAK, SFR2)
* *Lab 6*

Simulation of Multi-Node wells with MNW/MNW2

April 09 (blended)
9 am - 1 pm / 2:30 pm - 6:30 pm CET

* *Lab 7*
  - Robust NWT solver for MODFLOW
* *Lab 8*
  - Analysis of Water Budgets and simulating Sources of Water to Wells
* *Lab 9*
  - Manual approaches to Sensitivity Analysis and Calibration // Discussion of PEST
* *Lab 10*
  - Lecture: Modeling Guides (USGS/Haitjema)
  - Lecture: Common Modeling Errors
  - Lecture: Overview of Advanced MODFLOW Packages + Versions + Transport

April 10 (blended)
9 am - 1 pm CET

* *Modeling projects and homework*
  - Analysis of Pumping test with MODFLOW model (to be continued independently)
  - Dewatering problem: flow model construction, manual calibration, application, budget, and source analysis (to be continued independently)

Undressing MODFLOW (J. Doherty) – 11 h

The course is also available as a stand-alone online course.

May 6 (11 am – 1 pm CEST) Preliminary session

- Presentations and Introduction to the course
- Instructions for installing the software and access the e-learning platform
- A test model is provided to check that everything runs fine

May 13 (10 am -1 pm CEST)

Day 1: Grids

- Brief review of why a grid is needed. This is where mass is balanced, and the laws of groundwater flow and advective transport are formulated and enforced
- Structured and unstructured grids
- DIS, DISV and DISU grids
  - pinching out of layers
  - inactive and non-existent cells (IBOUND and IDOMAIN)
  - quadtree refinement and Voronoi grids
  - locations of cell vertices implicit in DIS but not in DISV or DISU (so cell vertex coordinates and intercell connection lengths and areas must be supplied directly)
  - the concept of "layer" is not fundamental to a DISU grid; connections are everything
- How cells are identified in DIS, DISV and DISU grids (icol,irow,ilay), (icpl,ilay), (inode)
- Cell neighbours
  - implicit in a structured grid
  - defined through IA and JA arrays in DISV and DISU grids
- Supplying grid specifications: DIS, DISV and DISU input files
- Grid coordinates and real-world coordinates
- The MODFLOW 6 GRB output file
- Visualizing a structured/unstructured grid:
  - GUI
  - FloPy
  - Some utilities of the PEST suite

May 20 (10 am -1 pm CEST)

Day 2: MODFLOW 6 Input files

- Text files in general: the importance of a suitable text editor and text differencing utility
- Packages and boundary conditions
- Stress periods and time steps
- The name file
- Package input files: arrays and tables
- Some examples of MODFLOW 6 package input files
  - NPF, WEL, GHB, SFR, RCH
- The importance of OPEN/CLOSE when using PEST/PEST++ (isolating parameterizable model inputs)
- MODFLOW 6 time series and array time series
- Viewing layer-specific arrays and reformatting them for GIS, SURFER, PARAVIEW, etc.
- Running MODFLOW 6 from the command line
- How much of your computer's resources is MODFLOW using?

May 27 (10 am -1 pm CEST)

Day 3: MODFLOW 6 Output Files

- Major output file types
  - list files
  - dependent variable files (text and binary)
  - cell-by-cell flow term files (binary only)
  - model-calculated observations
- Output file size
  - how to check
  - why it matters (parallel model runs writing to the same disk)
- The output control (OC) package
  - text or binary output
  - limiting output to times and types that are required (especially budget output)
- Identifying model problems using the list file
- Dependent variable files
  - array headers
  - the arrays themselves
  - how to inspect file contents
  - how to extract individual arrays
- Flow terms files
  - array headers
  - flow to/from boundary conditions
  - inter-cell flow terms
  - how to inspect file contents
- Extracting history-match-pertinent information from binary files
  - time interpolation
  - spatial interpolation
  - collecting flows to/from groups of boundary cells
- The MODFLOW 6 OBS package
  - protocol for input files
  - protocol for output files
  - A few words about how PEST and PEST++ interact with MODFLOW: "the model sandwich"

Module 2 (F. Lotti) – 12 h

May 8 (3-6 pm)

General Overlook about Model Calibration

- Principle of Parsimony and highly parametrized methods
- PEST in simple words
- Is model calibration really worth?

Workshop 2

MODFLOW 6 settings in ModelMuse. Getting familiar with the input/output files. Setting up observations and parameters.

May 15 (3-6 pm)

Workshop 3

Calibration with PEST: traditional approach based on uniform "zones". Sensitivity analysis, parameter correlation and troubles associated

May 22 (3-6 pm)

Pilot points

- Meaning, pros and cons, strategies and brief review of geostatistics needed to understand them.

Workshop 4

Calibration with PEST: pilot point approach (simplified)

May 29 (3-6 pm)

Regularization

- What is it about and why do we need it?

Workshop 5

Calibration with PEST: pilot point approach with regularization

Module 3 – Parameter estimation and uncertainty analysis using PEST/PEST++ (J. Doherty, F. Lotti) – 32 h

The course is part of the school programme but also available as a stand-alone.

September 8 (10 am–1 pm CET)
Optional on-line preliminary session

- A test model is provided to check that everything runs fine
- What to read to get a "foretaste" of issues related to model parameterisation

Workshop 1: videos and tutorials are provided to build a simple model using ModelMuse

September 14 (2-6 pm)

- Metrics for decision-support modelling
- Brief review of linear algebra and geostatistics
- What does "calibration" really mean?
- Bayes theorem, and how it is applied in groundwater modelling
- Predictive uncertainty and predictive error
- Old style calibration based on parameter parsimony: why it doesn't really work

Workshop 2: MODFLOW 6 and PEST settings in ModelMuse. Preparing for calibration.

September 15 (9 am-1 pm; 2-6 pm)

- The costs and benefits of parameter uniqueness
- Highly parameterized inversion and regularization
- Subspace methods including singular value decomposition
- Tikhonov regularization
- Pilot points as a parameterization device
- Construction of covariance matrices for parameter regularization and uncertainty analysis

Workshop 3: model calibration with pilot points.

September 16 (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
- Direct predictive hypothesis-testing

Workshop 4 - Post-calibration linear analysis.

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

- *Uncertainty in uncertainty: parameterizing the* prior
- Data space inversion
- Ensemble space inversion
- Hierarchical inversion
- How history-matching can do more harm than good

Workshop 4: nonlinear analysis of predictive uncertainty.

September 18 (9 am-1 pm)

- Optimization under uncertainty
- Data worth analysis
- Some considerations for contaminant transport modelling
- Some considerations for low enthalpy geothermal modelling
- "Group therapy": participants discuss their own problems

Field Hydrogeology Week

The course is also available as a stand-alone on-site course

	Activity	
October 09 *online* *3 pm – 6 pm*	• Overview of investigation methods. • Types of boreholes, constructions details.	• Site description, analysis of site material, GIS and available data.
October 13 onsite 12 am – 7 pm	• Measurement of borehole elevation, position and depth. • Video inspection of boreholes to define screen elevations. • Comparison with the available documentation. • Manual head monitoring. • Automatic diver set up and	• installation (to be left in the boreholes up to the end of the pumping test). • Vertical logging of EC and temperature. • How to sample from a piezometer and from a well, according to the purpose of the sampling.
October 14 onsite 9 am – 7 pm	• Organization of the manual measurements. • Geostatistical processing to obtain a potentiometric map according to different software and methods.	• Possible review of the automatic monitoring points. • Planning of a pumping test, preparation and check of the devices and data forms.
	• Pumping test start, troubleshooting, pumping test execution, troubleshooting, various attempts… etc. • Level monitoring in wells and piezometers.	• Discharge monitoring through different methods. • End of pumping, automatic monitoring of recovery during the night.
October 15 onsite 9 am – 7 pm	• Manual check of the levels. • Removal of the divers.	• Selection of points to perform slug-tests.
	• Download of the diver data, adjustments. • Organization of the manual measurements. • Processing of data according to different software and methods.	• Methods of river flow measurements. Planning of river discharge measurements, selection of meaningful sections.
October 16 onsite 9 am – 3 pm	• Upstream section preparation. • Measurement of river flow with flow meter and other devices.	• Downstream section preparation. • Measurement of river flow with flow meter and other devices.
October 23 *online* *9 am – 6 pm*	• Organization of the measurements. • Processing of the data according to different methods and comparison of results. Comparison of the different investigations results	• Estimate of aquifer parameters from river. Discussion about parameters, role of heterogeneity and how to transfer the acquired information into numerical models.
	• Discussion about “measurement noise” and how to translate it into “weights”.	• Sources of uncertainty. • Update of the conceptual model.

Recorded courses

Basics		Hours	Trainer	Lang.
Basic Hydrogeology 25 h	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*
Basic Contaminant Hydrogeology 20 h	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*
Basic methods 33 h	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*
Groundwater Engineering 8 h	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*
MODFLOW Conduit Flow Process (CFP) 10 h	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.	10:00	*T. Reimann, S. Birk*	*ENG*
FloPy and Py-EMU 11h	Before getting started. A first simple steady state and transient model. Flow and transport model building and predic-tive use. Model building with FloPy Pre-processing of data and building the model from YML notebook 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	11:00	*R. Hugman, M. Fienen, J. White*	*ENG*

Other recorded courses can be found on the SYMPLE website

Registration

Ente di Formazione Accreditato

Professional credits (**50 APC**) for Italian Geologists

Prices	Siamo presenti sul MEPA acquistinretepa	CARTA del DOCENTE SPENDI QUI IL TUO BUONO
Students - ECHN ~~1600 €~~ 1300 €*	SGI – IAH members ~~2500 €~~ 2200 €*	Regular ~~2700 €~~ 2400 €*
Registration form	**Payment information**	**Contact us**

***Early Bird Discount!!**
Register before July 17

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 younger than 35.

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

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