School of hydrogeological modelling & Project-related strategies

Ente di Formazione Accreditato — Consiglio Nazionale Geologi

UNDER THE AUSPICE OF iah aih Italian Chapter

On-site Course 2026

Time series modeling of Groundwater levels with Pastas

Save the week of April 13th-17th, 2026, Milan, Italy

Course overview

Time series analysis provides a framework to study aquifer response without requiring a complete physical description of the subsurface. Through a data-driven approach, the observed signal can be decomposed into the contributions of different processes controlling groundwater dynamics, quantify response times, and support management decisions. For a more detailed overview, see: Bakker and Schaars (2019). In many cases, attempts to reproduce complex realities through highly detailed physically based models may lead to over-complex numerical models with limited predictive capability, whereas time series models focus directly on reproducing and interpreting observable system behaviour.

This workshop introduces groundwater time series analysis using impulse response functions, with hands-on exercises using the open-source Python package Pastas. Participants will learn how to use Pastas to describe and predict groundwater level fluctuations. By the end of the course, they will be able to:

- Identify and quantify the influence of hydrological forcings such as precipitation, evaporation, groundwater pumping and surface water levels;
- Apply data-driven time series models to solve real-world groundwater problems;
- Choose an appropriate time series model structure taking into account forcings, trends, and nonlinearity;
- Manage and evaluate large datasets efficiently.

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Course Programme

The workshop is designed to be highly interactive. You can expect:

- **Presentations** on the mathematics, concepts and logic behind time series models using response functions.
- **Hands-on exercises** applying the theory in Jupyter Notebooks with examples and exercises
- **Interactive discussions** and plenty of opportunities to discuss your specific data challenges with the developers and fellow participants.

Day 1

- ✓ Introduction to time series analysis and its applications
- ✓ Time series analysis with response functions
- ✓ Time series modeling with multiple stresses

Day 2

- ✓ Nonlinear recharge models
- ✓ Uncertainty quantification
- ✓ Model your own time series

Day 3

- ✓ Modeling large datasets
- ✓ Model evaluation in practice (Pastas for Decision Support)
- ✓ Current and future research (forecasting, signatures, numerical models)

Requirements: no previous experience with time series modeling is required, but familiarity with Python is required to successfully complete the in-class exercises performed in Jupyter Notebooks. If your Python level is not sufficient, you can get up to par with some excellent free online material such as this MOOC (https://programming-26.mooc.fi/) or GitHub repository (https://github.com/mbakker7/exploratory_computing_with_python).

What is included

- Access to live lessons
- Material to carry out the exercises
- Access to our e-learning platform to watch again the recorded lessons
- *APC credits* for Italian Geologists on request
- Coffee breaks & Lunches

Costs

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

- Regular: **600 €**
- Students: **300 €**
- Installments available

To bring: A laptop (and charger) with a Python installation (installation instructions will be provided)

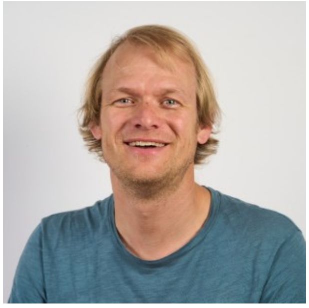
Registration form

Seats are limited to **35 participants**

Register preferably before March 23rd, 2026

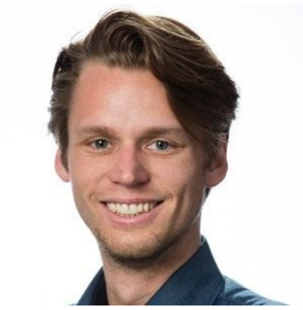
Trainers

The course will be taught by a rotating lineup of the Pastas developers. This ensures that each topic is taught by an expert in the field.

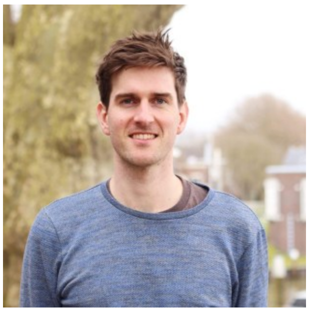


Raoul Collenteur (Collenteur HydroConsult GmbH)
Raoul is a senior hydrologist and the lead developer of Pastas, the Python package for modeling groundwater time series. He specializes in developing advanced modeling techniques for nonlinear groundwater recharge and short-term forecasting. Following his PhD at Graz University, Raoul held a postdoctoral research position at Eawag and served as a scientific staff member at the Federal Office for the Environment (FOEN) in Switzerland. Recently, he founded Collenteur HydroConsult, providing specialized consultancy in the field of groundwater hydrology.

Mark Bakker (Delft University of Technology)
Mark is a groundwater engineer and a professor of groundwater dynamics at the Delft University of Technology in the Netherlands. Mark has taught Python programming and groundwater modeling for over 20 years and is the (co)-developer of several open-source Python programs for groundwater modeling (TimML and TTim) and time series analysis (Pastas), and was one of the originators of the FloPy package to run MODFLOW from Python.



Davíd Brakenhoff (Artesia / Delft University of Technology)
Davíd Brakenhoff is a hydrogeologist at Artesia specializing in numerical groundwater modeling, analytical element and time series analysis. Davíd is a core developer of Pastas and he has authored packages within the pastas ecosystem including PastaStore for large-scale data management and Metran for multivariate time series analysis. He is a part-time researcher at Delft University of Technology focusing on using analytical element models in numerical modelling.



Onno Ebbens (Artesia)
Onno is a hydrological consultant with over a decade of experience and a background as a teacher. He has trained over 250 professionals in Python programming, specializing in making coding accessible to those with no prior experience. Additionally he was a high school teacher in informatics. Onno bridges the gap between hydrology and software by mentoring participants to develop their own project-specific (Python) applications.

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Ruben Caljé (Artesia)

Ruben Caljé is a hydrologist at Artesia with over 15 years of experience in numerical groundwater modeling. His main focus is on numerical groundwater models with density dependent flow and salinization. Additionally, he is a specialist in groundwater time series analysis with Pastas, data validation and app development.

Martin Vonk (Artesia / Delft University of Technology)

Martin is a PhD researcher at TU Delft and a geohydrological consultant at Artesia. His expertise spans unsaturated zone modeling, drought analysis, and time series analysis, where he contributes to the Pastas ecosystem and developed SPEI, a specialized Python package for drought quantification. His research focuses on integrating time series models with numerical groundwater models to accurately quantify pumping effects on groundwater heads.

Read about Pastas!

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- Jenny T. Soonthornrangsan, Mark Bakker, and Femke C. Vossepoel. Linked Data-Driven, Physics-Based Modeling of Pumping-Induced Subsidence with Application to Bangkok, Thailand. *Groundwater*, October 2024. URL: https://doi.org/10.1111/gwat.13443 (visited on 2024-10-13), doi:10.1111/gwat.13443.
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