Course guide
250MAG008 - 250MAG008 - Stochastic Methods in Hydrology

Last modified: 22/06/2025

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.

Degree: MASTER'S DEGREE IN WATER ENGINEERING (Syllabus 2025). (Optional subject).

Academic year: 2025 **ECTS Credits:** 5.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: GUILLEM SOLÉ MARÍ

Others: GUILLEM SOLÉ MARÍ
XAVIER SANCHEZ VILA
MICHELE STARNONI

TEACHING METHODOLOGY

There are 3 hours per week of face-to-face classes in the classroom. In these classes, concepts and content are explained, with examples and problem solving.

Applied sessions that require the use of computer tools take place in the computer lab, unless all students prefer to use their laptops in the classroom.

The main and supplementary support materials will be provided through the ATENEA virtual campus.

LEARNING OBJECTIVES OF THE SUBJECT

By the end of the course, students will be able to:

Understand the fundamentals of statistics applied to hydrology and hydrogeochemistry.

Manipulate and analyze hydrological data using programming tools such as Python and scientific libraries.

Apply descriptive and inferential statistical techniques to environmental datasets.

Identify and quantify temporal and spatial patterns in hydrological data.

Estimate return periods and fit extreme value models for risk assessment.

Develop hydrological forecasting models based on observational data.

Apply multivariate analyses such as principal component analysis (PCA) in hydrogeochemical contexts.

Understand and apply geostatistical methods for spatial interpolation and simulation of hydrological variables.

Interpret statistical results within the framework of real-world engineering and environmental science problems.

STUDY LOAD

Type	Hours	Percentage
Hours large group	45,0	36.00
Self study	80,0	64.00

Total learning time: 125 h

CONTENTS

Introduction to the course and review of basic statistical concepts

Description:
Course introduction; Review of basic probability and statistics: distributions, means, standard deviation, percentiles; Sampling, measurement errors and statistical inference: estimation and hypothesis testing.

Full-or-part-time: 8h 20m
Theory classes: 3h
Self study : 5h 20m

Statistical analysis of hydrological data using Python

Description:
Python setup and environment: Jupyter, scientific packages (NumPy, SciPy, Pandas, Matplotlib); Data manipulation with Pandas: import, cleaning, grouping and summarizing; Descriptive statistics and correlations: metric calculation, correlation matrices; Data visualization: line plots, scatter plots, histograms, maps and customization.

Full-or-part-time: 25h
Theory classes: 9h
Self study : 16h

Advanced applications of statistical analysis in hydrology and hydrogeochemistry

Description:
Analysis of hydrological time series: seasonality, trends, autocorrelation, spectral analysis; Return periods: extreme value distributions, fitting and validation; Hydrological and rainfall forecasting models: regression, ARIMA, introduction to machine learning techniques; Principal component analysis (PCA) in hydrogeochemistry: dimensionality reduction, result interpretation.

Full-or-part-time: 41h 40m
Theory classes: 15h
Self study : 26h 40m

Geostatistics applied to hydrology

Description:
Basic concepts and regionalized variables; Stationary and second-order random functions; Semivariogram and its relation to covariance; Variogram inference: sample semivariogram computation and interpretation; Theoretical variogram models: exponential, spherical, Gaussian and nugget effect; Spatial structure analysis: variability scales, anisotropy and nugget effect; Ordinary kriging: formulation and application; Universal kriging and residual kriging; Cokriging and kriging with external drift; Co-located cokriging and practical applications; Introduction to geostatistical simulation; Sequential simulation and Monte Carlo method; Applications to mapping of hydrogeological variables.

Full-or-part-time: 50h
Theory classes: 18h
Self study : 32h

GRADING SYSTEM

Practical assignments are proposed to be completed at home during the course, and an exam is held at the end of the semester.

The final grade is calculated as
FG = 0.6 * EG + 0.4 * PG,
where EG is the exam grade and PG is the average grade of the practical assignments.

BIBLIOGRAPHY

Basic:
- Freeze, R. Allan; Cherry, John A. Groundwater. Englewood Cliffs (N.J.): Prentice-Hall, cop. 1979. ISBN 9780133653120.
- McKinney, Wes. Python for Data Analysis: Data Wrangling with Pandas, Numpy, and Jupyter [on line]. 3rd ed. Sebastopol, CA: O'Reilly Media, 2022 [Consultation: 25/06/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=29441847. ISBN 109810403X.
- Cressie, Noel A.C. Statistics for Spatial Data [on line]. Rev. ed. New York: Wiley, 1993 [Consultation: 02/07/2025]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9781119115151. ISBN 0471002550.
- Helsel, Dennis R.; Hirsch, Robert M.; Ryberg, Karen R.; Archfield, Stacey A.; Gilroy, Edward J.. Statistical Methods in Water Resources [on line]. USGS, 2020 [Consultation: 25/06/2025]. Available on: https://pubs.usgs.gov/publication/tm4A3.