UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

CONSIGLIO INTERCLASSE IN MATEMATICA

COURSE OF STUDY — TWO-YEAR MASTER OF SCIENCE PROGRAMME IN MATHEMATICS

ACADEMIC YEAR — 2023-2024

ACADEMIC SUBJECT — DATA ANALYSIS AND NUMERICAL ECOLOGY

General information	
Term	Second semester (February 26, 2024 – May 31, 2024)
European Credit Transfer and Accumulation System credits (ECTS)	7
SSD	MAT/08 – Numerical Analysis
Language	Italian
Mode of attendance	Not mandatory

Lecturers		
Name and surname	Luciano Lopez (instructor of record)	Giuseppe Vacca
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Telephone	+39 080 544 2678	+39 080 544 2645
Department and office	Department of Mathematics room 15 second floor	Department of Mathematics room 12 second floor
Virtual meeting room		
Web page	https://www.dm.uniba.it/it/members/lopez	https://www.dm.uniba.it/it/members/vacca
Office hours	Monday and Wednesday 11:00-13:00 and byappointment via email	appointment via email

Work schedule	Total	Lectures	Hands-on learning (recitations)	Self-study
Hours	175	48	15	112
ECTS credits	7	6	1	

Learning objectives	
	Acquiring methods and techniques of applied mathematics for the observation and analysis of data from an ecological/environmental study. Learning of the numerical methods for the discretization of partial differential equations (PDEs). Simulation of environmental models described by PDEs.

Course prerequisites	
	Basic knowledge of Analysis, Algebra of matrices, numerical analysis, statistics, and of a programming language, knowledge acquired in the Bachelor of classL-35.

Syllabus	
Course contents	***Data analysis*:** objects and descriptors in ecology; the ecological matrix. Binding arrays of objects and descriptors.. Association measures: similarity and distance. Statistical dependence of descriptors in ecology. Scattering matrix for descriptors. Covariance matrix and correlation matrix. Multivariate

	normal distribution. Determination of the principal axes of ellipsoid. Analysis of type R and type Q: similarity coefficients (symmetric and asymmetric) and coefficients of distance between pairs of objects. Distances: metrics and semi-metrics. ***Cluster analysis***: Hierarchical methods: the single link, complete link, average, weighted average, the centroid, minimum variance or Wart. Partitional methods: k-means methods and variants. **Principal component analysis (PCA):** Sorting in smaller spaces. Principal components of a data matrix, of the correlation matrix and of the normalized correlation matrix. The SVD and the Bi-plot. Factor Analysis and PCA. The PCA for functions of data (FPCA). Computational methods. Examples. Factorial Analysis. ***Introduction to the Data Assimilation:*** the variational and the statistic-algebraic approach. Construction of operators to minimize. Examples and applications for determining the parameters for models described by partial differential equations (PDEs). ***Numerical Methods for the approximation of PDEs:*** elliptic and parabolic PDE, strong formulation and variational formulation. Finite Differences Method. Galerkin method: Lax-Milgram Lemma, Cea Lemma. Finite element method: mesh, construction of the finite element spaces and discrete forms, convergence results. Coding of the P1 element. Mathematical model for canal pollution and atmospheric pollution.
Reference books	P. Legendre, L. Legendre, **Numerical Ecology,** Elsevier 1998. E. Holzbecher, ***Environmental Modeling,*** Springer, Berlin, 2007. J. W. Thomas, ***Numerical partial differential equations: finite difference methods,*** Springer, New York, 1995. A. Quarteroni, A. Valli**,** ***Numerical Approximation of Partial Differential Equations*****,** Springer Science & Business Media, 2008.
Additional course materials	Notes provided by the teachers.
Repository	

Expected learning outcomes	
DD1 Knowledge and understanding	Acquisition of the techniques to analise data in multidimension. Acquisition of basic concepts of ecological/environmental for the analysis of problems.
DD2 Applying knowledge and understanding	Acquisition of numerical methods for data analysis and simulation of environmental models and interpretation of results.
DD3-5 Soft skills	*DD3 Making judgements*: Ability to evaluate the results from a study of an ecological problem through the tools of applied mathematics.
	DD4 Communication skills: Acquisition of the mathematical language in describing a ecological problem and its simulation.
	DD5 Learning skills: Acquisition of appropriate learning methods, through the systematic use of texts, exercises and computer simulations of models.

Teaching methods	
	Lessons in the room and lab with the help of slides and auxiliary material.

Assessment	
Assessment methods	At the end of the course and before the exam, two projects will be proposed, one on the Data Analysis part and the other on the modeling part, which will be adequately developed.

Evaluation criteria	• *Knowledge and understanding*: Acquisition of techniques of treatment of mutimensional data. Acquisition of basic concepts of ecological/enviromental problems and their simulation. • *Applying knowledge and understanding*: Acquisition of numerical methods for ecological data analysis and simulation of environmental models and interpretation of *results.* • *Making judgement*: Ability to evaluate the results from a study of an ecological problem through the tools of applied mathematics. • *Communication skills*: Acquisition of advanced mathematical language in describing a ecologicalproblem and its simulation. • *Learning skills*:Acquisition of appropriate learning methods, through the systematic use of texts, exercises and computer simulations of models.
Grading policy	The final score varies between 18/30 and 30/30, and will be attributed on the basis of the development capacity of the assigned projects and the clarity of the exposure.

Further information	
	Attendance is not mandatory but strongly recommended .