

Mathematical and statistical modeling of complex systems



ECTS credits
5 credits

In brief

> **Course language:** French

Presentation

Prerequisites

Mathematics: probability/statistics

Learning objectives

- Know the theory of discrete and continuous time dynamical systems.
 - Know the theory of stability.
 - Know the theory of differential equations.
 - Know the theory of estimation and detection for extreme phenomena.
 - Be able to choose the appropriate tools for modeling a phenomenon.
 - Be able to implement a model with evaluation of the parameters and to illustrate the different behaviors through simulations.
 - Know how to use or develop appropriate numerical methods to efficiently solve a problem.
 - Master the computer tools necessary for the numerical implementation of models.
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Description of the programme

Mathematical Modeling of Complex Systems I and II (30 hrs: 9-7-14-0)

Discrete models, continuous dynamical systems, associated numerical methods; partial differential equations, numerical methods and examples of applications in biology.

The Lorenz system: a simple model in meteorology (15 hrs : 10-5-0-0)

General introduction (meteorology, Lorenz discovery, Rayleigh-Benard convection and the Lorenz system); Rayleigh-Benard instability (linear stability theory; fundamental equations and Boussinesq approximation; basic flow and linearization of equations; dimensionless equations: Rayleigh and Prandtl numbers; transition from conduction to convection); chaos (notion of attractors and sensitivity to initial conditions; study of the Lorenz system. Numerical simulations of the Lorenz system).

Extreme values (19 h : 6-6-7-0)

Extreme values, order statistics, domains of attraction of a distribution of extreme values, Hill estimator, Pickands estimator, tails of distribution, behavior of excesses, Pareto law, Gumbel law, Weibull law. Use of R or Matlab software.

Generic central skills and knowledge targeted in the discipline

Competency 2 COMPLEXITY

- Defines a problem in a simple system, positions it in its environment and proposes a relevant model.
- Understands and uses a given complex model (multi-component and multidimensional)
- Models a multidimensional system with interdependent and/or nondeterministic components. Makes assumptions and conditions of validity.
- Experiences the unpredictability of a complex system (disturbances, potential risks, etc.)

How knowledge is tested

DS1 : Dynamic systems 25

CC1 : Dynamic systems (homework) 15

CC2: Dynamical systems (homework) 10

DS2 : Lorenz model 17

CC3 : Lorenz model (practical work) 8

CC4 : Extreme values (homework) 25

Bibliography

English Course Handout

Teaching team

- * Malek Abid (Aix-Marseille Université)
- * Guillaume Chiavassa
- * Jacques Liandrat
- * Christophe Pouet

Sustainable Development Goal



Climate action

Total des heures		64h
CM	Master class	25h
TD	Directed work	18h
TP	Practical work	21h

Useful info

Name responsible for EU

Lead Instructor

Christophe Pouet

✉ christophe.pouet@centrale-med.fr