Mathematical and statistical modeling of complex systems

ECTS credits
5 credits

In brief

Course langage: 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.

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

Frédéric Schwander

frederic.schwander@centrale-med.fr