Laurea Magistrale
Atmospheric Science and Technology (LMAST)

SUBJECT TITLE	Physics of non-linear systems
TEACHER NAME(S)	Guglielmo Lacorata
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Teacher office address	CNR ISMAR, Area della Ricerca di Tor Vergata, Via Fosso del Cavaliere 100, Roma
DISCIPLINE (SSD)	FIS/06 (Physics of the Earth and of the circumterrestrial medium)
Semester (1-4) and location	N/A, Univ. of L'Aquila
Credits (CFU/ECTS)	6
Lecture hours (h)	60 (45 lectures + 15 numerical exercitations)
Prerequisite and learning activity	Classical Mechanics, Calculus, Programming
Teaching language and method	English; lectures, exercises and homework
Assessment method	Oral examination and discussion of the numerical exercitations
SUBJECT WEBSITE	N/A

OBJECTIVES

Main goals are:
-To recall the basics of the theory of dynamical systems and deterministic chaos;
-To introduce standard techniques for the characterization of chaotic dynamics;
-To present applications of dynamical system theory in Geophysics;
-To train the students to numerical exercitations.

OUTCOMES (Dublin descriptors: knowledge, understanding, explain, skill, ability)

After the successful completion of this module, the student should be able to:
-know the main concepts related to non linear dynamics and predictability;
-measure the characteristic quantities related to a dynamical system or a chaotic signal;
-set up and analyse numerical simulations of simple nonlinear models;
-know the main applications of the dynamical system approach to Geophysical problems.

PROGRAM CONTENT

INTRODUCTION. Basic definitions. Dynamical systems and maps. Linear stability. Lyapunov exponents. CHARACTERIZATION OF CHAOS. Maximum Lyapunov Exponent. Information entropy. Fractals. Strange attractors. Stable and unstable manifolds. TRANSPORT, DIFFUSION AND MIXING. Basic equations. Eulerian and Lagrangian chaos. Turbulence. FINITE-SCALE PERTURBATIONS. Generalization of the Lyapunov Exponent. Relative dispersion. Lagrangian measures. CHAOS IN GEOPHYSICS. Simplified earthquake models. Mixed layer models. Nonlinear jet currents. NUMERICAL EXERCITATIONS. Simulations of conservative and dissipative systems. Lorenz models. Kinematic models.

REFERENCES AND MATERIAL

-E. Ott, Chaos in dynamical systems, Cambridge Univ. Press, 2002.
-A. Crisanti, M. Falcioni, G. Paladin and A. Vulpiani, Lagrangian chaos: transport, mixing and diffusion in fluids, Il Nuovo Cimento, 1991.
-Material provided by the teacher during the course.