

Dottorato XXXIV ciclo

Sustainable Agricultural and Forestry Systems and Food Security

Title: Mathematical Methods and Computational Tools for the Modeling and Analysis of Complex Biological Systems

Potential tutor

Prof. Francesco Giannino

Objectives and multidisciplinary collaborations

Ecosystems may respond gradually (and thus predictably) to external human and/or environmental disturbance or they may change their equilibrium state in a sudden and sharp manner. It is now well accepted that such sharp change (catastrophic transitions) may be explained with the existence in the ecosystems of two or more stable states. Indeed, alternative states have been found in many ecosystems and many studies have explained mathematically catastrophic transitions in terms of possible regime shifts and/ or bifurcations.

For this reason, modelling of complex biological systems still continues to be a very important topic, due to its substantial impact on simulation, design, optimization and control of processes. Models have different degrees of complexity from the simple “black box” models to the “cybernetic” approach.

In this context, dynamic systems where vegetation-environment feedbacks are present are of particular challenge and the mathematical models are able to predict and reveal the mechanisms underlying emergent behaviour (e.g. phase transitions between stationary states, sustained oscillations, travelling waves and spatio-temporal chaos). Examples of real world biological systems that undergo such behaviour include but are not limited to ecology, vegetation dynamics, agricultural and forestry systems and parasitology, tumor growth, brain dynamics and epidemiology.

Progress beyond the state of the art

We aspire to develop and employ (beyond the) state-of-the-art methodologies from numerical analysis, dynamical systems, control and optimization coupled new machine and manifold learning methods that will make possible the construction of both individual based models and coarse-grained models and bridge the gap between time and spatial scales between them. We will apply these methodologies to real biological cases (agricultural and forestry systems).

Research funding

- MOD_DEV_CELL "System dynamics modeling of microbial cell cultures: numerical methods, process optimization, and individual-based approach", coordinator: Francesco Giannino.
- TECNOAGRICOLA “Nuove TECNOlogie a supporto di nuove coltivazioni e di nuovi scenari nell’AGRIColtura moderna” PSR CAMPANIA 2014/2020, scientific coordinator: Francesco Giannino,

Collaboration with foreign institutions

- Prof. Constantinos Siettos, National Technical University of Athens/University of Naples
- Dott. Christian Vincenot, Kyoto University, Biosphere Informatics Laboratory, Department of Social Informatics
- prof. Max Rietkerk, Utrecht University, Copernicus Institute of Sustainable Development