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MATHEMATICAL MODELLING AND SIMULATION FOR ECOLOGICAL SYSTEMS

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ABSTRACT

The study of ecological and technological systems, and the effective management of natural resources, require reliable mathematical and computational tools to understand their dynamics and predict their evolution. The underlying physical and biological processes are often characterized by strong nonlinearities and multiple interacting mechanisms operating across different spatial and temporal scales. These features pose significant challenges in both formulating appropriate mathematical models and obtaining accurate solutions at a reasonable computational cost. Physical and biological insight should therefore guide model formulation, while the analysis of the resulting mathematical structures can inform the design of robust numerical methods.

The aim of this session is to bring together researchers working on mathematical modeling and numerical methods for ecological and technological systems. Contributions addressing both methodological developments and specific applications are welcome, with particular emphasis on the interplay between model formulation, theoretical analysis, and numerical simulation.

Topics of interest include, but are not limited to:

- mathematical modelling of physical and biological processes using deterministic and stochastic differential equations;
- stability and bifurcation analysis of nonlinear systems, with particular attention to the emergence of Turing patterns;
- accurate and efficient numerical methods for stiff and multiscale problems;
- structure-preserving numerical methods that reproduce qualitative properties known a priori for the continuous model;
- parameter estimation and uncertainty quantification;
- integration of mechanistic models with data-driven approaches, including machine learning and artificial intelligence techniques.

Applications of interest include vegetation dynamics, sustainable agriculture, water resource management, pollutant transport, battery performance, material deterioration, and the modelling and optimization of energy systems and industrial processes.