GENERAL DIRECTION "MODELING"

KEYWORDS: MATHEMATICAL, NUMERICAL, COUPLED METHODS, REDUCED MODELS, IDENTIFICATION AND OPTIMISATION

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MAJOR RESEARCH UNITS INVOLVED: LIRMM, L2C, IMAG, IES, MISTEA, INRIA (EX-MODEMIC / LEMON)

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EXAMPLES OF CROSS COOPERATION: UMR CBS: CENTRE DE BIOCHIMIE STRUCTURALE; UNIVERSITÉ DE GUYANE (LABEX CEBA); UMR BPMP: BIOCHIMIE ET PHYSIOLOGIE MOLÉCULAIRE DES PLANTES, UMR GÉOSCIENCES MONTPELLIER, UMR AMAP: BOTANIQUE ET MODELISATION DE L'ARCHITECTURE DES PLANTES ET DES VEGETATIONS; UMR INSTITUT CHARLES GERHARDT

EXAMPLES OF INTERNATIONAL COOPERATION: UNIVERSITY OF BERKLEY (USA), ECOLE POLYTECHNIQUE FÉDÉRALE, LAUSANNE (SUISSE), UNIVERSITY OF GRATZ (AUSTRIA), UNIVERSITY OF CHILE (CHILE), SOUTHERN FEDERAL UNIVERSITY (RUSSIA)

HIGHLIGHT: JOINT WORKSHOP WITH LABEX AGRO AND CEMEB ON "MODELING AND NUMERICAL SIMULATIONS OF THE PLANT" (2017); GRISBI ("GROUPEMENT DE RECHERCHE INTERDISCIPLINAIRE SUR LES SYSTÈMES BIOLOGIQUES) INTERNATIONAL WORKSHOP ON "BIOPHYSICS: TODAY AND BEYOND" (WITH LABEX EPIGENMED, 2018).

Objectives

This GD aims at promoting mathematical or numerical representations of the physical world in relation to applications involving living and environmental systems. This GD interacts naturally with the "Algorithms & Computations" GD projects at the frontier between the numerical and physical worlds, such as image or statistical analysis, and with the «model systems and measurements» GD whenever models require the development of original experimental approaches for input data or validation – with applications typically in agromaterials (wheat, gluten, algae, wood…), environmental fluids, microbes and pathogens, blood, DNA, etc.

The description of complex flow within blood vessels[1], together with observations on the process of Malaria parasite egress from blood cells (within the "model systems and measurements" GD) and their physical modeling contributed to the integrated project "Blood complex system".

A working group supported since 2011 devoted to studying of the interactions between fluids and living matter developed a model (and associated software) that combined the equations of hydrodynamics and biochemical reactions (Fig. 1). A working group contributed to the initial construction in 2016 of the INRIA team "Lemon" on Methods and tools for Litoral and Environment, a joint IMAG and INRIA project that was started in 2017. Two research projects were supported through a Post-Doc, on modeling and optimization of activated sludge bioreactors for wastewater treatment[2], and a PhD (starting in 2018) on hydro-ecological

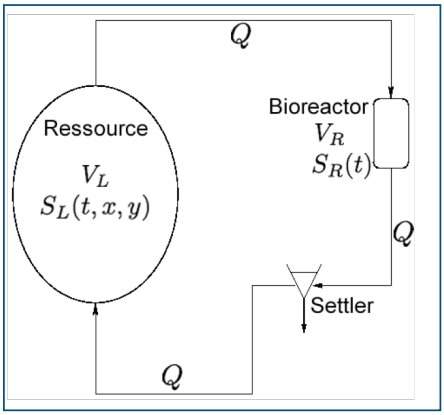

Fig. 1: Principle of Modeling the remediation of lakes using bioreactors[2]

modeling.

Functioning mechanisms are studied at all scales (which is one of the originalities of the GD Modeling), from the structuring of polymer gels via catalytic reactions at the molecular level, to starting projects on the radial diffusion of water in roots[3], the biomechanical role of bark in tropical tree species (Postdoc, started in October 2017, jointly funded with LabEx CEBA), individual-based models of bacteria, and species interactions in microbial ecology at the scale of a population. The same can be said for environmental applications ranging from the description of hygro-poro-mechanical couplings in soils[4] or poroelastic media[5], optimization of bioreactors for wastewater treatment and improvement of desalination techniques based on thermomechanical analysis (equipment for the Dunetec start-up), to the inverse analysis of GPS data of surface movements to estimate lithosphere rigidity at the continental level (Fig. 2)[6].

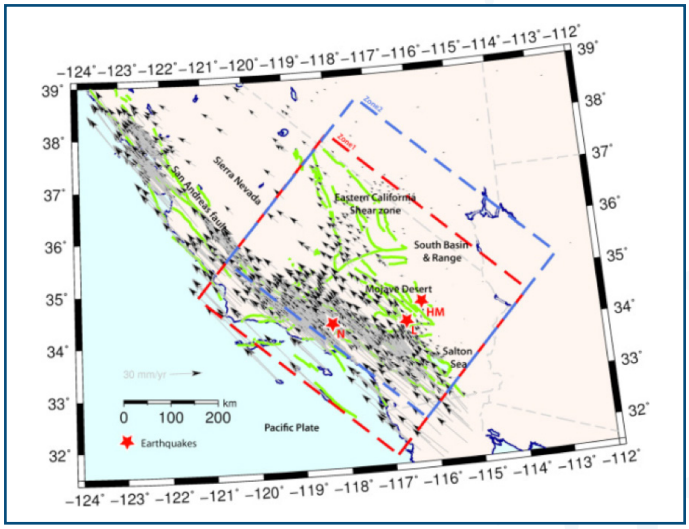

Fig. 2: Adaptive and robust inversion of geodetic data at the continental scale: Model prediction of weak rigidities on the San Andreas Fault6

Advanced methods to predict anisotropic elasticity of wood[7] were performed on local pine species in view of their use by designers for high added value products. A study on the impact of wooden beehives on bee health and beekeeper practice has led to a multidisciplinary project combining material science and electronics, as well as biology, agronomy, anthropology, neurology. Recently an interdisciplinary project bringing together chemists (cooperation with LabEx Chemisyst), biologists, doctors and biomechanics on the reconstruction of joint cartilage by stem cell techniques was supported by the LabEx. This project, combining modelling and experimentations, has the promising objective of reconstructing functional cartilage for joints worn out by osteoarthritis[7].

In addition to PhDs, postdocs, projects and meetings, this GD supported several networks and interdisciplinary working groups: GRISBI ("Groupement de Recherche Interdisciplinaire sur les Systèmes Biologiques") with in 2018 international workshop in Montpellier on Biophysical modeling with 100 attendees.

In May 2017, a workshop on "Modeling and numerical simulations of the Plant" was organised jointly with LabEx AGRO and CeMEB to initiate communication between local research groups from various communities. Digital plant modeling and simulation is becoming a scientific and societal challenge motivated by the need to better understand the interactions between plants and their environment (soil, root) and dedicated projects will start in this direction with the objective of proposing a flagship project.

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