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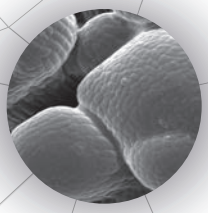
Expertise of the scientific community in the Occitanie area (France)

COMPLEX SYSTEMS

From biology to landscapes



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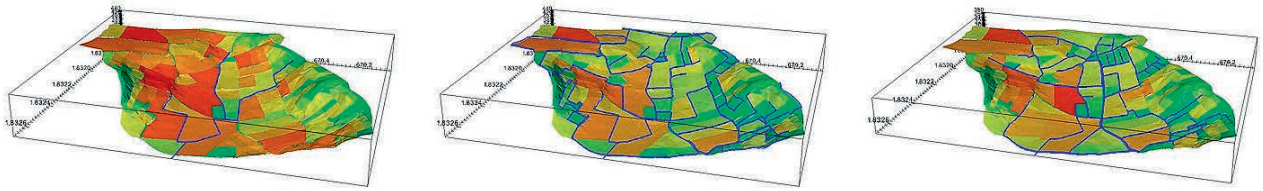
OpenFLUID Plateform – spatial modelling of complex landscape functioning

Understanding how cultivated landscapes work is a major environmental management challenge, particularly in terms of integrating agriculture into a sustainable development and quality approach. Such landscapes embody many geographical features, biophysical and socioeconomic processes, whose dynamics are spatially distributed, with strong interactions, even feedback, between them. A landscape system is therefore highly complex, and such systems are studied over large spatiotemporal areas mainly via modelling. Tools are essential to gain insight into such features. Development of the OpenFLUID platform has therefore been under way since 2005 for the spatial modelling of complex landscapes.

OpenFLUID proposes a spatiotemporal landscape modelling framework based on: (i) a representation of spatial organization in the form of space graphs, and (ii) a system for coupling dynamic models, plugged into the platform on request. The space graph representation obtained from geographical data includes landscape features (graph nodes: plot, river section, road section, underground, atmosphere, etc.), and relationships between these features (arcs on the graph that link the nodes). The coupled models use this space graph to simulate the landscape's spatiotemporal dynamics. OpenFLUID—with advanced nested graph and variable time step coupling features—allows the use of multiscale modelling approaches. The OpenFLUID platform is a complete software environment built around a modelling and simulation framework: model development, capitalization and sharing, application preparation, simulations and processing of the results. The platform also offers various bindings and interconnections with programming languages and third-party tools, including the R environment to address, for example, multisimulation research needs.

Contact: J.-C. Fabre (UMR LISAH), jean-christophe.fabre@inra.fr
For further information: www.openfluid-project.org



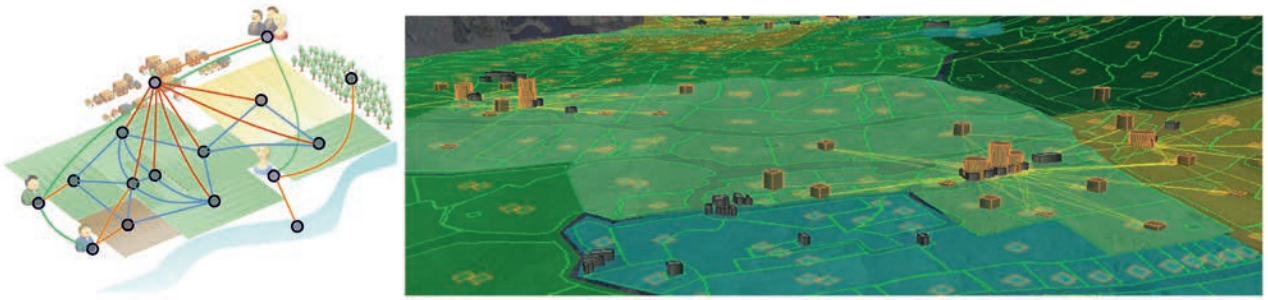
▲ *Example of multisimulations to determine the optimum density and spatial organization of a hydrographic network so as to limit erosion hazards in agricultural plots connected to this network.*

Ocelet modelling platform – simulating spatial dynamics *via* interaction graphs

The Ocelet platform is used in different disciplines to build simulation models for studying phenomena that are expressed spatially in territories. Among the other tools and approaches designed for this purpose, Ocelet stands out by the use of the interaction graph as the basic concept underlying the model building process. Graphs are simply sets of nodes, some of which are connected by arcs. The interaction graph is defined as a graph where the arcs are able to hold interaction functions. Any system to be modelled is thus viewed as a set of interconnected entities, while the execution of interaction functions leads to changes in the related entities thus prompting the system to evolve. Note that this same concept enables a unified representation of spatial entities in vector and raster formats for their joint use in models.

The Ocelet software environment and its dedicated modelling language offer a limited number of formally defined concepts that are essential for modellers. The user interface includes various functions for model creation and maintenance, Ocelet source editing, compilation, simulation launching, display and exportation of simulation results, particularly in the form of animated maps. The Ocelet modelling language enables users to model—with considerable freedom of expression—a segment of the concerned territory and the underlying processes in order to simulate its evolution over time. Models have been developed in various fields, e.g. coastal dynamics of mangrove ecosystems, mosquito population dynamics to support vector control, prospective simulation of urban sprawl scenarios, and agrarian dynamics in a cotton cropping area in Burkina Faso. The software and user manual are available online at the Ocelet website.

Contacts: P. Degenne, pascal.degenne@cirad.fr and
D. Lo Seen, danny.lo_seen@cirad.fr (UMR TETIS)
For further information: www.ocelet.fr



▲ *Interaction graphs and agricultural biomass transfer modelling in Réunion.* *P. Degenne, 2018, GABiR project.*