



# Pitfalls about Validation of agent-based simulation

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## Outline

- Pitfalls of this presentation
  - Being either too general or either too technical
  - Validation discussion could degenerate into a massive riot between disciplines
- Main messages
  - Comparison of simulation results with empirical data is a criterion among others for the evaluation of how good a model is
  - It is not always either necessary or even pertinent
  - Robustness is not a property an Agent-Based model necessarily should have

# CAPSIS Simulation Platform

- <http://capsis.free.fr>
- Simulation of forest growth
- Enabling the organization of tree-cutting campaigns by forest managers
- IBM approach
- Wanted property
  - Reliability of results



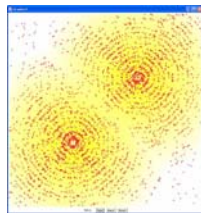
## Reliability of results

- Robustness of results
  - You want to avoid, on a first simulation run to have to cut 10 trees of the A species and on a second run to have to cut 300 trees of B species
- Reliability of model structure: verification
- Reliability towards data: calibration, validation
- Data available for calibration/validation:
  - Data available about forest growth for more than 200 years both at the forest and the tree level on several sites
  - Trees are not much sensitive to the Internet revolution

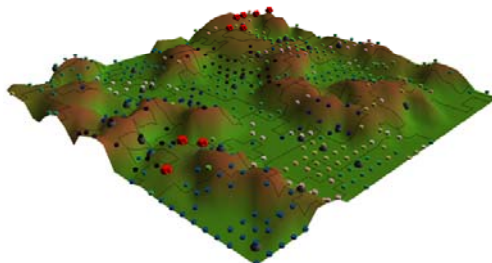


## Some definitions

- Verification: Do I have implemented the model I wanted to implement i.e. without bugs?
- Calibration: from a large potentiality of behaviours I want to put the model in the zone of the parameter space where it has wishable properties (i.e. robustness + where it fits some data gathered A)
- Validation: I want to test the generalization (not the genericity) of the model to other contexts (test if it fits data sets B, C, D)



Does ABM for Social Sciences  
enters really in such a framework?





## Back to basics...

« Individual-Based Modelling is Modelling... »

*(Volker Grimm)*

- Models are always imperfect
- The value of a model has to be evaluated taking into account the aim of the model
  - Necessity of having a Modelling question
  - The Model is a tool regarding the question



## Description vs. Understanding

« *Prédire n'est pas expliquer* »

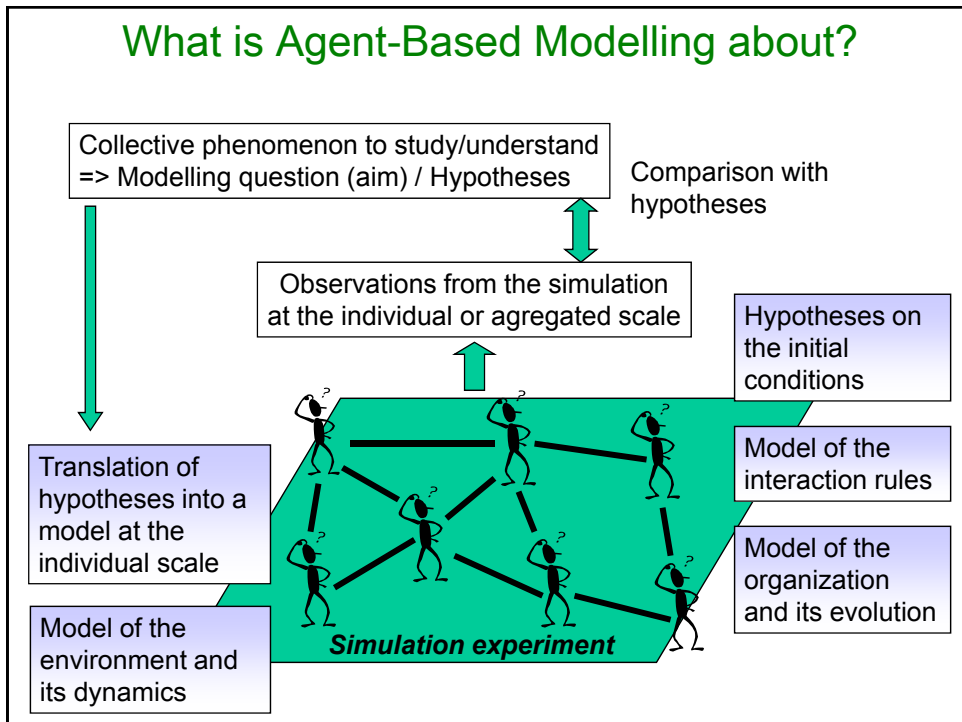
René Thom

« *Expliquer n'est pas prédire* »

Frédéric Amblard

- How do we usually build agent-based models (at least in Social Sciences)?

# What is Agent-Based Modelling about?



## Simulation to compute

- Simulation can be seen as a mean of calculating the consequences of hypothesis that human being can not compute
- Dynamical hypotheses
- Distributed system
- Multiple, possibly parallel, interactions
- Simulation like an in-silico projection of the hypotheses...





## Main questions linked to an ABM approach

- How/which macro behaviour is produced by micro hypotheses + interaction + organization + ...
- Having an understanding => trying to build a « theory » of the micro/macro link in the specific case of the experiment
- Try to generalize this « theory »



## The virtual experimental approach



## The virtual experimental approach

- Having built your model, you have a perfect object for experiments
  - Replicable at the identical (RNG)
  - Change the instrument of measure (but most of the time you have to build them)
  - Automation of the experiments
  - Measures without bias

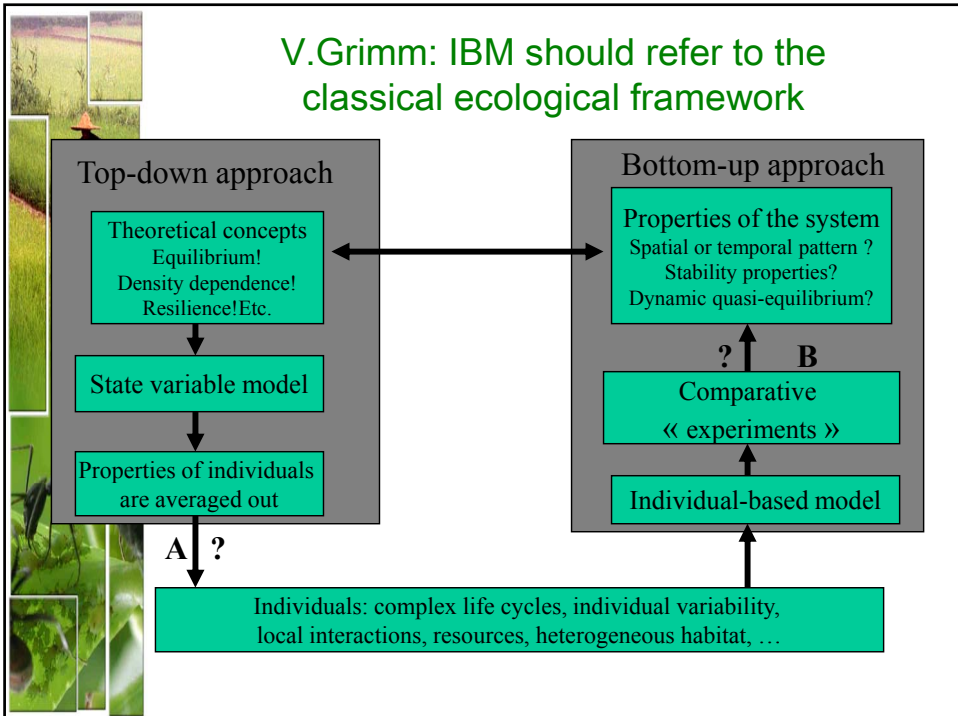


## Towards virtual laboratories

- In order to build the virtual laboratory
  - Instruments to measure => Indicators
  - Facilitate the building and the replication of the experiment
  - Facilitate the execution of the experiment (optimize)
  - Experimental design methodology (Kleijnen)
- Build model(s) of the model to understand its functioning
  - Multi-modelling
  - Articulation between paradigms (formalisms or viewpoints)

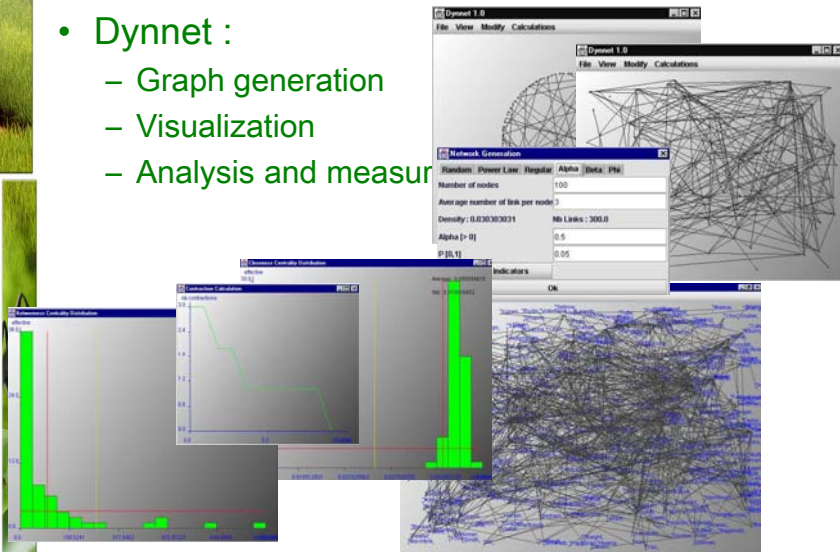
## Comparison of models

- Starting from a model
  - Re-implement it using the same language
  - Using another language
  - Using another paradigm of modelling
- Compare what is comparable (outputs of the model at the individual level, at the aggregated level, etc...)
- Work on similarities/dissimilarities



# Tools to visualize and measure the interaction graph

- Dynnet :
  - Graph generation
  - Visualization
  - Analysis and measurement

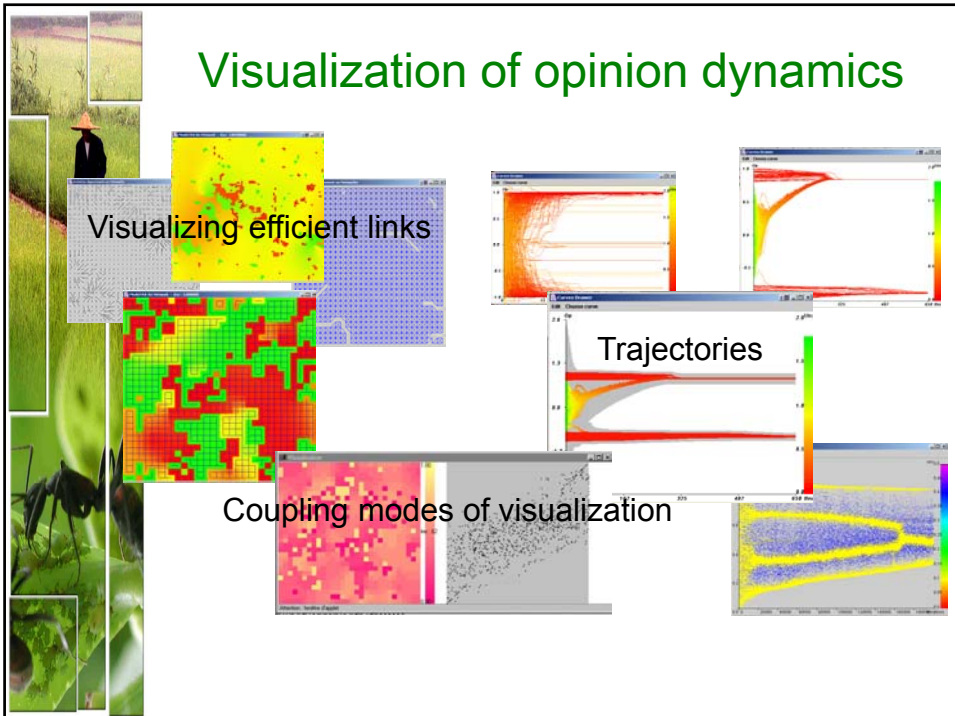


# Visualization of opinion dynamics

Visualizing efficient links

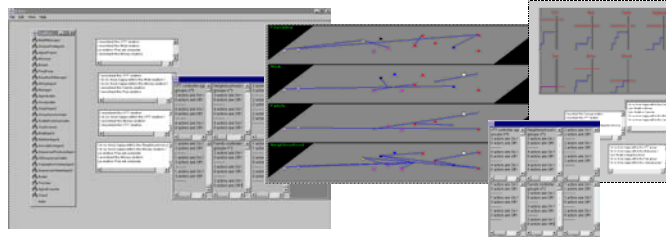
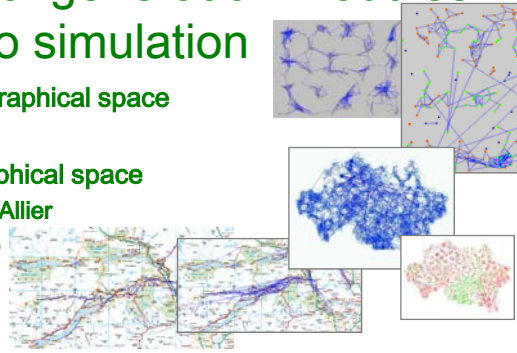
Trajectories

Coupling modes of visualization



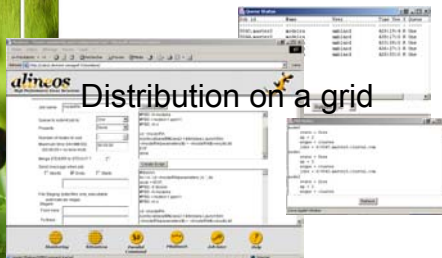
# Integration of generation modules to simulation

- From a virtual geographical space
- From a real geographical space
  - Département de l'Allier
  - Breadalbane (UK)
- Simulation of the formation of multiplex networks



# SimExplorer

Prototype for the management of experimental designs





## Validation questions



## Back to basics... J.-M. Legay (1973)



- Validation is a decision based on validity criteria
  - None of them, taken isolately, has a decisive value
  - The whole set of criteria enables to describe a profile of the studied model and to take the decision



## Criteria for validity

- Usefulness: results and success it provokes
  - Ex: Exponential Model for growth phenomena
- Simplicity (KISS)
  - Not a quality as such
  - Necessity to take into account the complexity of the reality
- Universality/Genericity
  - Non decisive criterion
  - A general model can be not adapted for the study of particular phenomena



## Criteria for validity

- Non contradiction
  - The model should respect the relations verified experimentally
  - Statistical techniques to test the correspondance ( $\chi^2$  test)
  - Non contradiction means that the model is not to be rejected, not that it is satisfying nor the best
- Convergence
  - The validity of a model grows with its use (i.e. the nb of independant experiments which confirm the model)
- Non-identity
  - A model is efficient because it differs from the subject



## From models to understand to models to act



## Companion Modelling approach

- Modelling process involving final users or field actors...
- Aims
  - Eliciting strategies/rules of decision-making
  - Coordinating strategies for the management of renewable resources





## Companion Modelling approach

- What to validate: the model(s), the process?
- How?
- Nils Ferrand (Research/action context):
  - Who is the final user of your model?
  - Who is your customer?
  - Who will evaluate your model or modelling process?



## Models for decision-makers

- Decision-makers as the final users
- Qualitative comparison of scenarios/policies
- Modelling is no more a thought experiment
  - For instance: no more opinion dynamics but opinion dynamics about the simplified constitution project in Lalonde les Maures...
  - Importance of calibration: feeding the model with empirical data



## Comparison with data

- Ideally you would need
  - Longitudinal data (trajectories of individuals) for (nearly) any attribute
  - Information about the environment and its dynamics
  - Information about the localization of the individuals and their movements
  - The social network structure and its evolution
  - ...
- Most of the time ABMs generate much more data than the empirical data you have...
- Then you can only make a partial evaluation ...



## Calibration question

- Distribution of agents' attributes that have the same structure than gathered empirical data
- Measuring indices that can be related to measured empirical data...
- Validation: you have to test the model with independent sets of data (usually other case studies => another phase of calibration)



## Question of robustness

- Need the model to be robust in order to make a decision?
- What does it mean if it is not?
- What does it mean concerning the system if you obtain
  - Multimodal distribution
  - Instability
  - Bifurcation
  - Sensitivity to initial settings...
- Does it really makes sense for the decision-maker?



## Conclusion

- Agent-Based Modelling is most of the time a thought experiment mediated by computer
- That you eventually and partially can bring closer to the target system by feeding it with empirical data (a more realistic thought experiment)
- But, most of the time the understanding of the calculated consequences of the micro hypotheses are not understood



## Questions ???

## Comparaison du résultat qualitatif / données i.e. à vue d'oeil

Nombre d'agriculteurs dans les différentes phases de décision

