

# VISUAL ANALYTICS OF SPATIO- TEMPORAL SIMULATION DATA: EVALUATION OF A MODEL OF SPATIAL REORGANIZATION IN NORTH-WESTERN EUROPE, A.D. 800 TO 1100.

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UNIVERSITÉ PARIS 1 – PANTHÉON-SORBONNE

UMR GÉOGRAPHIE-CITÉS





- TRANSMONDYN RESEARCH PROJECT (LENA SANDERS) :  
STUDYING THE TRANSFORMATIONS OF THE SETTLEMENTS  
SYSTEMS, OVER THE LONG TIME

→ HOW DO SPATIAL STRUCTURES EVOLVE THROUGH TIME ?

→ ARE THERE REGULARITIES IN THEIR TRANSFORMATIONS ?

→ CAN WE PROPOSE SOME COMMON EXPLANATIONS TO CHANGES THAT  
OCCURED AT DIFFERENT PLACES, AT DIFFERENT TIMES, AND AT DIFFERENT SPACE AND  
TEMPORAL SCALES ?



# CASE STUDY

800



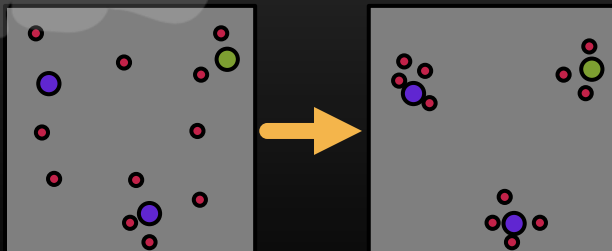
1100

- THE *TRANSITION* IN THE SETTLEMENT SYSTEM OF NORTH-WESTERN EUROPEA BETWEEN 800 A.D AND 1100 A.D

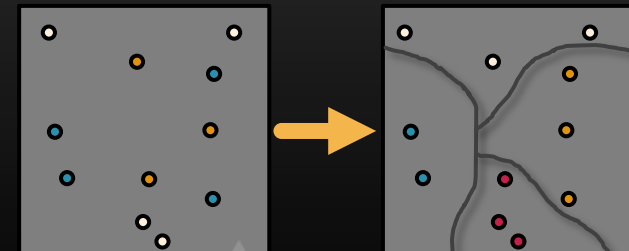


→ A DOUBLE PHENOMENON

CLUSTERING



«TERRITORIALIZATION»



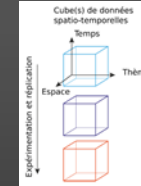
# APPROACH

## Questioning



Data gathering

Sources



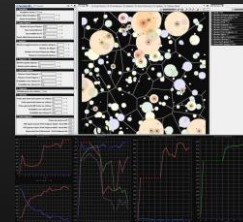
Simulated data

Sources analysis

Simulation



Modelling



Hypotheses

Model

# APPROACH

## Questioning



Data gathering

Sources



Confrontation



Simulated data



Sources analysis

Confirmation / Refutation

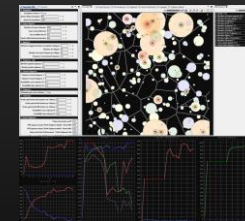
Validation

Simulation



Hypotheses

Modelling



Model

# MODELLING

Questioning

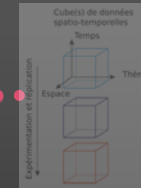
Data gathering



Sources



Confrontation



Simulated data

Sources analysis

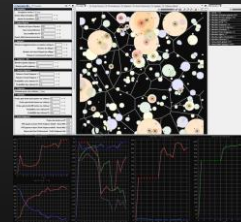
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Modelling



Hypotheses

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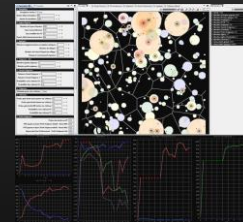
# MODELLING

- THEMATIC HYPOTHESES :
  - THE CLUSTERING OF THE SETTLEMENT SYSTEM IS DUE TO THE JOINT EFFECT OF :
    - THE CENTRAL AUTHORITY DILUTION (GLOBAL);
    - LORDS' RIGHTS CRUMBLING (LOCAL) ;
    - THE APPEARANCE AND ROLE OF PARISHES.

→ HOW CAN WE TEST THOSE HYPOTHESES ?



→  
Modelling



Hypotheses

Model



# MODELLING

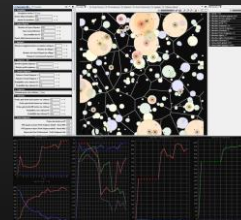
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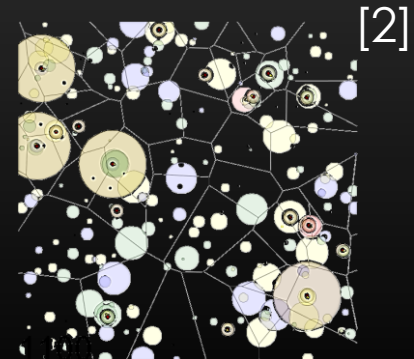


Hypotheses

➔  
Modelling



Model






# MODELLING

## What are we modelling ?

How individual seignorial strategies affect the peasant behaviors through the territorial network of castles and churches ?

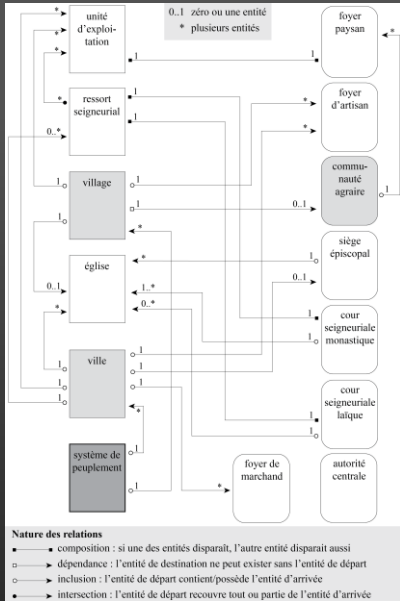
How individual peasant's reactions affect the pattern of the settlement system ?



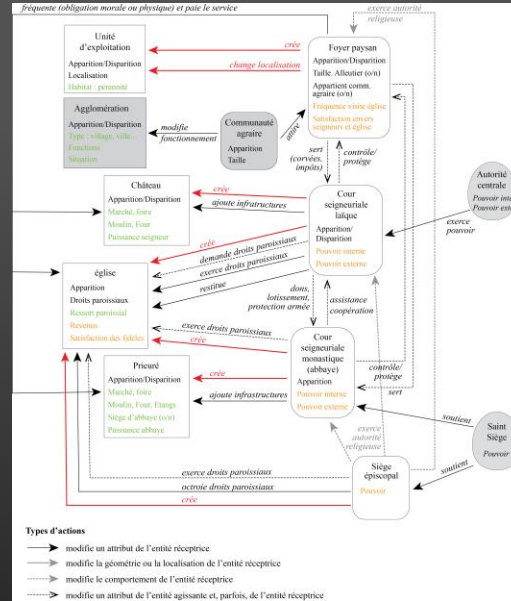
Self-organization and emergence  
in a complex system

# MODELLING

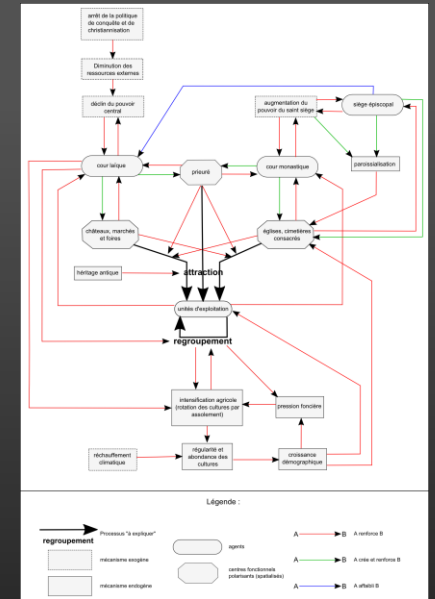
## Which modelling process ?



Entities



Actions



Interactions

Actors with behaviors  
=  
Agents with rules

# MODELLING

Two types of social agents

Peasant Households

Lay Lords



« Undergoers » agents

→ Move

→ Reshape the space



Cluster in villages (5-10 P.H.) and small towns ( $\geq 30$  P.H.) :  
→ The « Agregates »



« Acting » agents

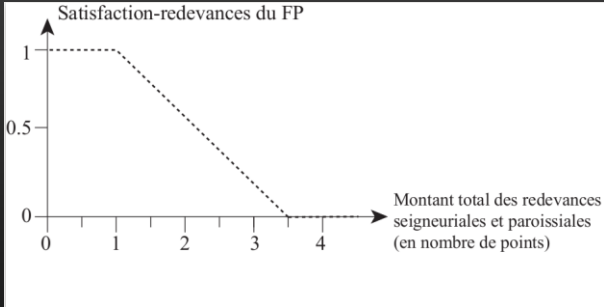
→ Drive the changes



Collect dues, build and give castles

# MODELLING

## Peasant Households

Goals	Actions	Measures								
Ensure their spiritual salvation	<ul style="list-style-type: none"><li>• Go to church</li><li>→ Move closer to parish churches</li></ul>	<ul style="list-style-type: none"><li>• Time-dependant function of the distance toward a church/parish</li></ul>								
Fulfill their material needs	<ul style="list-style-type: none"><li>• Minimize dues</li><li>→ Move away from high-dues lands</li><li>• Increase productivity</li><li>→ Move closer to agrarian communities and villages/towns</li></ul>	<ul style="list-style-type: none"><li>• Function of the amount of dues to pay</li></ul>  <table border="1"><caption>Satisfaction-redevances du FP</caption><thead><tr><th>Montant total des redevances seigneuriales et paroissiales (en nombre de points)</th><th>Satisfaction-redevances du FP</th></tr></thead><tbody><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td></tr><tr><td>3.5</td><td>0</td></tr></tbody></table>	Montant total des redevances seigneuriales et paroissiales (en nombre de points)	Satisfaction-redevances du FP	0	1	1	1	3.5	0
Montant total des redevances seigneuriales et paroissiales (en nombre de points)	Satisfaction-redevances du FP									
0	1									
1	1									
3.5	0									
Avoid being abused	<ul style="list-style-type: none"><li>• Get under the protection of a powerful lord</li><li>→ Move closer to a castle owned by a powerful lord</li></ul>	<ul style="list-style-type: none"><li>• Time-dependant function of the distance toward a castle and its owner</li></ul>								

# MODELLING

## Peasant Households

### Overall Satisfaction

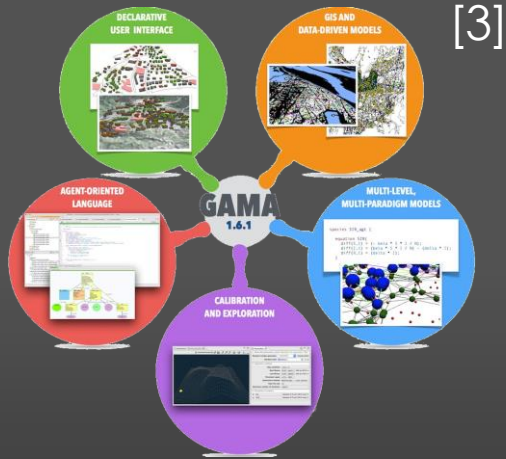
Religious	Material	Protection
<ul style="list-style-type: none"><li>• Time-dependent rules of proximity towards a parish church</li></ul>	<ul style="list-style-type: none"><li>• Function of the number of dues to pay</li></ul>	<ul style="list-style-type: none"><li>• Time-dependent function of the military power of their lord protector</li></ul>

$$Satisfaction [0; 1] = \min([S_{religious}, S_{protection}]) - (1 - S_{material})$$

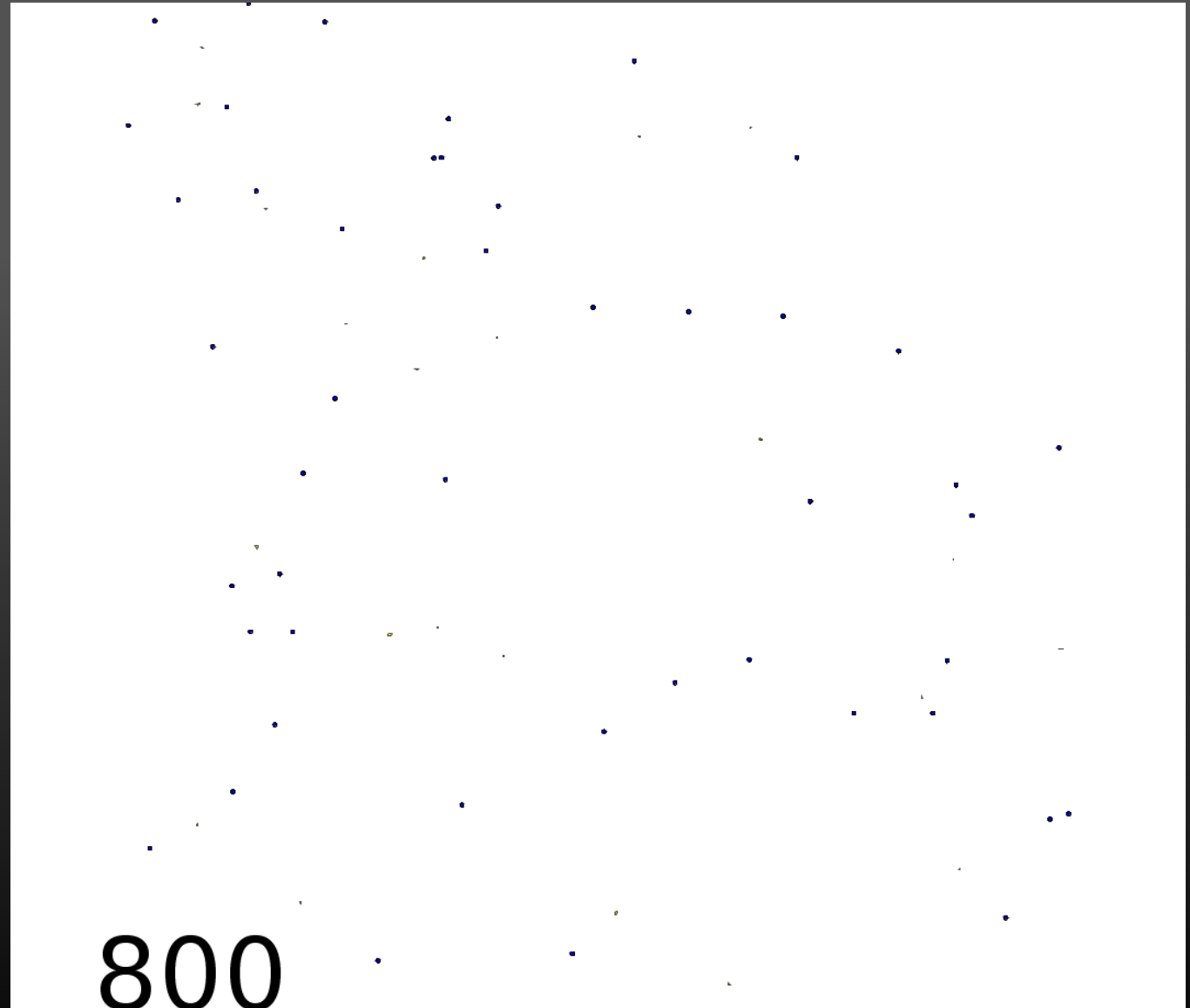
A peasant household tries to improve his Satisfaction

→ Through moving away, when unsatisfied  
 $Moving\_Probability = 1 - Satisfaction$

# MODELLING



[3]

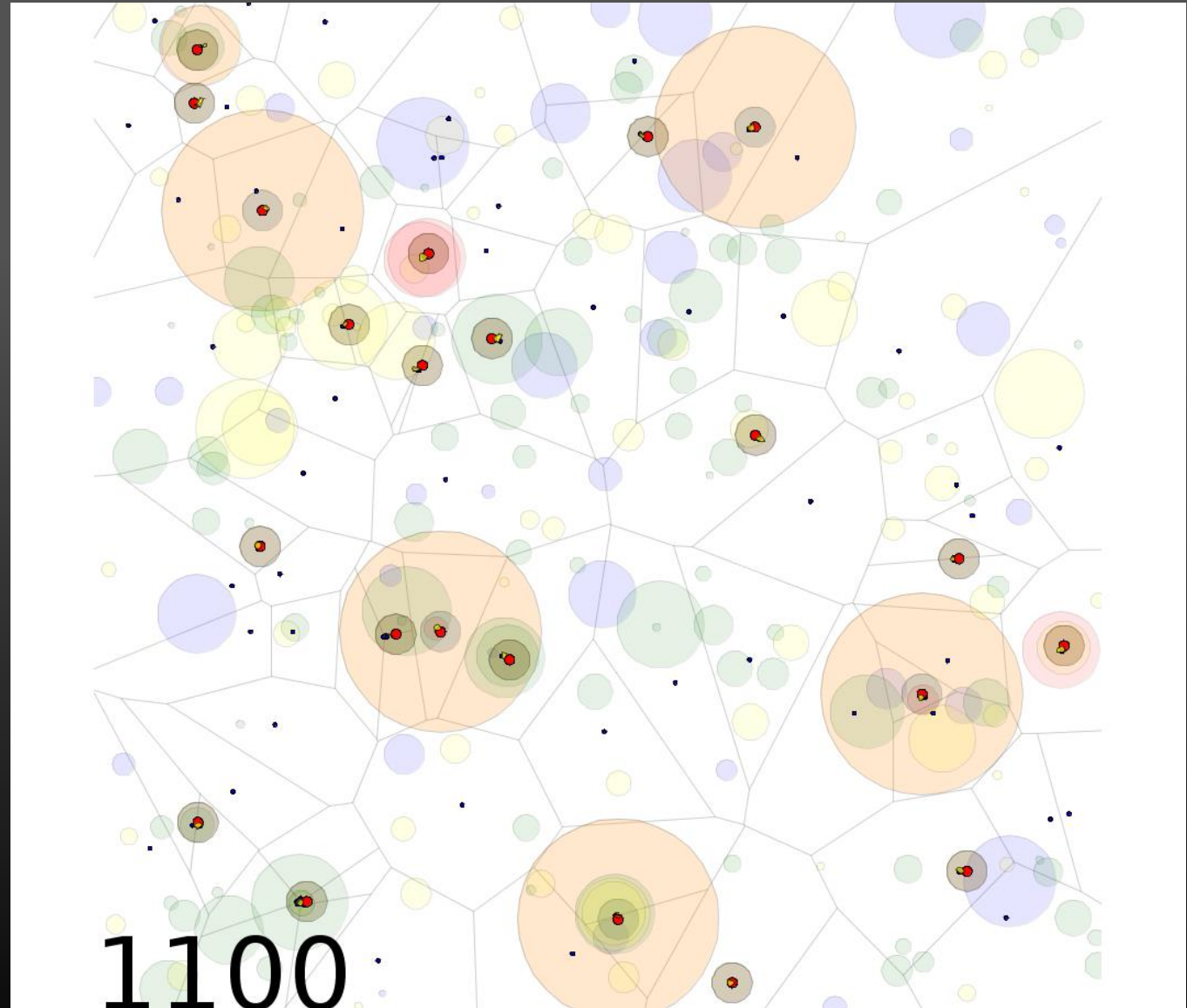
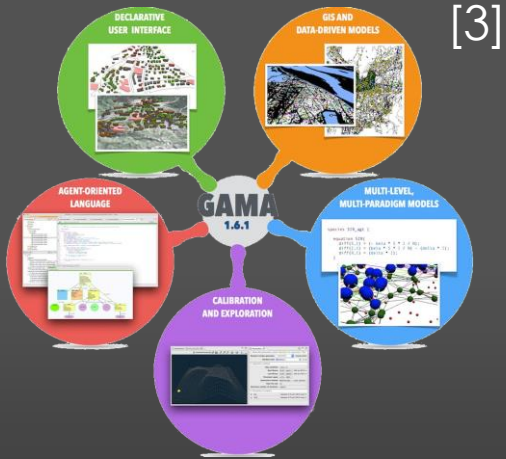


[2]

[2] Fixation & Polarisation – R. CURA - <http://github.com/RCura/transition8>

[3] GAMA (1.6.1) – GAMA Team - <http://gama-platform.org>

# MODELLING



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# SIMULATION

## Questioning



Data gathering

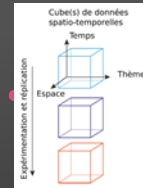
Sources



Sources analysis

Confrontation

Confirmation / Refutation



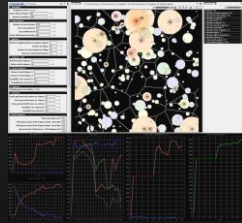
Simulated data

Validation

Simulation



Modelling



Hypotheses

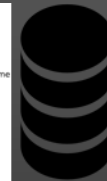
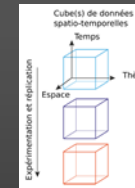
Model

# SIMULATION

- A MODEL WITH (TOO?) MANY PARAMETERS

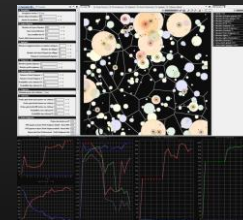
- SOME OF THEM BASICALLY BEING IMPLEMENTATION DETAILS

- SOME OF THEM LINKED WITH EACH-OTHERS



Simulated data

simulation



Model

Parameters Console

Simulation

Enregistrer sorties?  true

Année début simulation 800

Année fin simulation 1160

Foyers Paysans

Nombre de Foyers Paysans: 4000

Taux renouvellement 0.05

Taux mobilité des FP 0.8

Année début besoin protection 900

Agréats

Nombre d'agglomérations secondaires antiques: 3

Nombre de villages: 20

Nombre de Foyers Paysans par village: 10

Puissance Communautés Agraires 0.5

Seigneurs - Init

Nombre grands seigneurs 2

Nombre petits seigneurs 18

Grands Seigneurs

Puissance Grand Seigneur 1 5

Puissance Grand Seigneur 2 5

Probabilité créer château GS 1.0

Probabilité don château GS 0.33

Seigneurs

Châtelain peut créer château  false

Châtelains

Proba. gain droits haute justice sur château 0.1

Proba. gain droits banaux sur château 0.1

Proba. gain droits BM Justice sur château 0.1

Probabilité créer château PS 1.0

Probabilité don château PS 0.15

Petits Seigneurs

Proba. don droits sur ZP 0.33

%FP payant un loyer (Petit Seigneur initial) - Borne Min 0.05

%FP payant un loyer (Petit Seigneur initial) - Borne Max 0.25

Rayon min Zone Prélèvement - Petits Seigneurs Init 1000

Rayon max Zone Prélèvement - Petits Seigneurs Init 5000

Nombre visé de seigneurs en fin de simulation 200

Proba d'obtenir un loyer pour la terre (Petit Seigneur nouveau) 0.1

%FP payant un loyer (Petit Seigneur nouveau) - Borne Min 0.0

%FP payant un loyer (Petit Seigneur nouveau) - Borne Max 0.15

Rayon min Zone Prélèvement - Petits Seigneurs nouveau 300

Rayon max Zone Prélèvement - Petits Seigneurs nouveau 2000

Petits Seigneurs

Proba gain nouveaux droits banaux 0.05

Proba gain nouveaux droits BM justice 0.05

Eglises

Nombre d'églises: 150

Dont églises paroissiales: 50

Probabilité gain des droits paroissiaux 0.05

Nombre max de paroissiens 60

Nombre min de paroissiens 10

Model t8\_model Parameters for experiment 'Exp\_Graphique'

Random number generator [mersenne] among [cellular, xor, java, mersenne]

Random seed  Define: 0.0

# SIMULATION

- A MODEL WITH (TOO?) MANY PARAMETERS

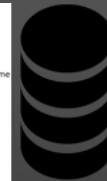
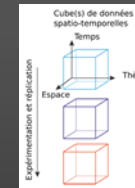
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- SOME OF THEM LINKED WITH EACH-OTHERS

→ WE NEED TO HIDE THE COMPLEXITY ...

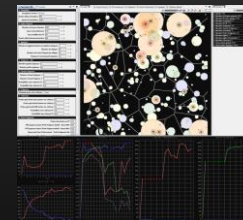
TOWARDS A SIMPLIFICATION OF THE

PARAMETERS

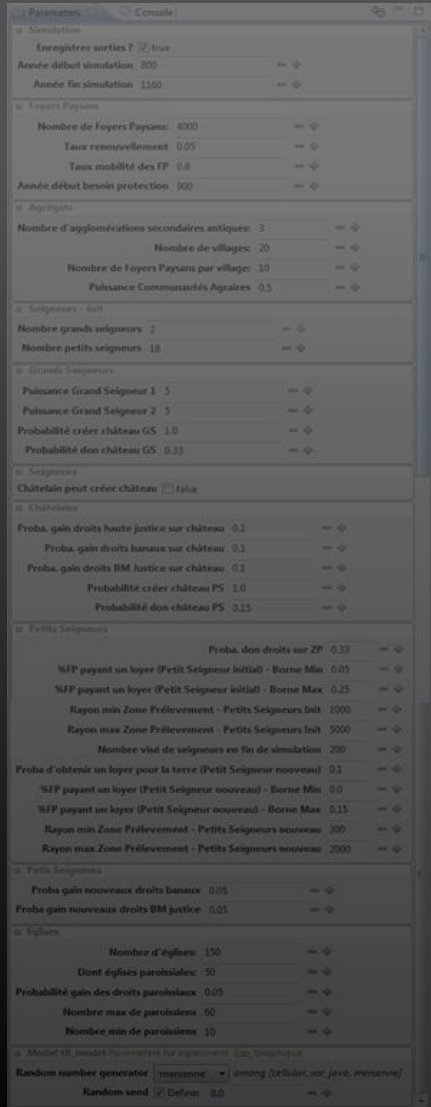


**Simulated data**

↑  
*simulation*



**Model**



# SIMULATION

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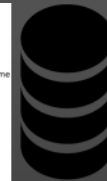
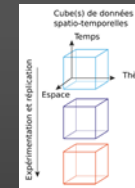
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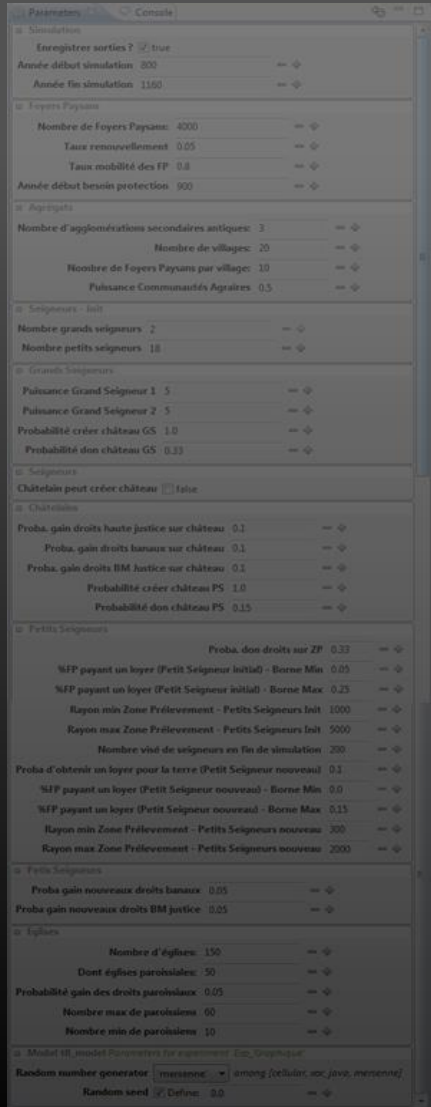
TOWARDS A SIMPLIFICATION OF THE PARAMETERS

We need a user-friendly tool to let final users run themselves the experiments !

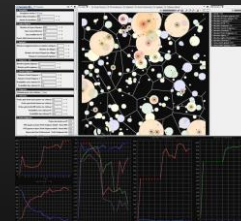
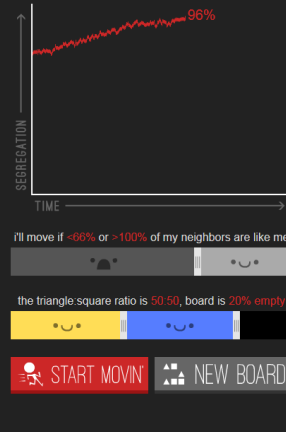
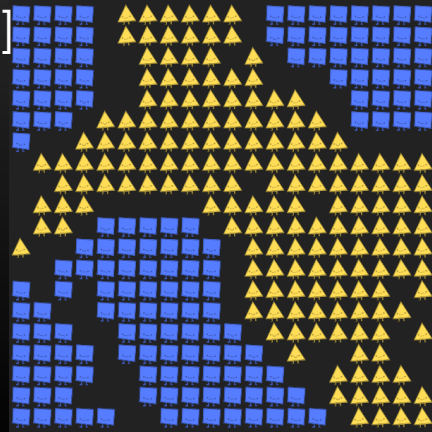


Simulated data

simulation



[4]

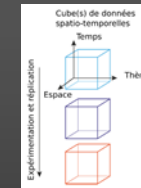


Model

[4] Parable of the polygons– V. HART & N. CASE - <http://ncase.me/polygons/>

# SIMULATION

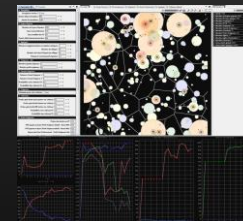
- A FUNDAMENTALLY STOCHASTIC SIMULATION MODEL
  - A VIRTUAL LABORATORY, ENABLING EXPERIMENTS AND REPLICATIONS
  - A LARGE AMOUNT OF DATA TO BE ORGANIZED, TO ALLOW THE PARAMETERIZATION AND CALIBRATION



**Simulated data**



How to analyze such data ?



**Model**

# EXPLORATION

Questioning

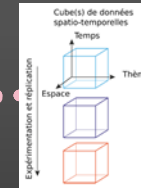


Data gathering

Sources



Confrontation



Simulated data

Sources analysis

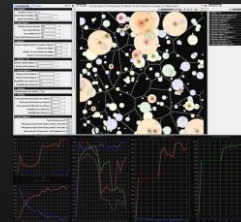
Confirmation / Refutation

Validation

Simulation



Modelling

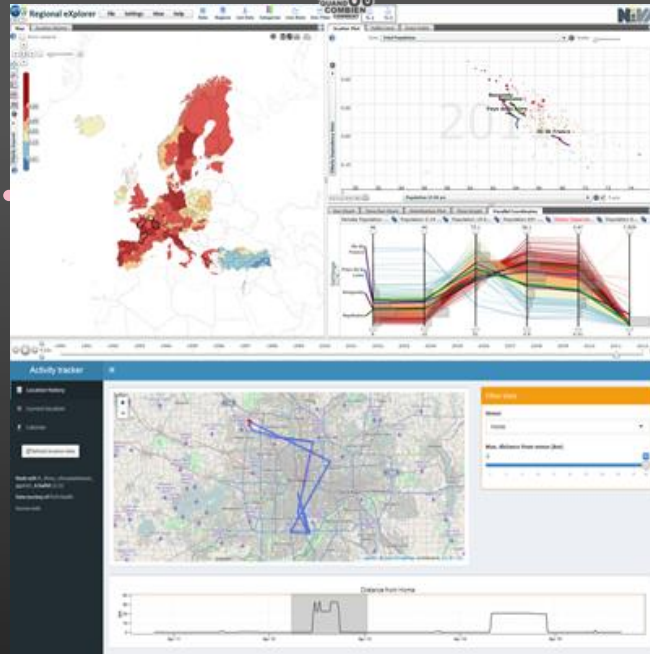


Hypotheses

Model

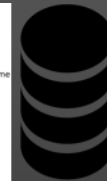
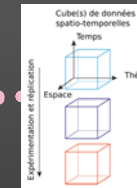


# EXPLORATION

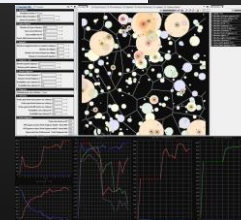


[5]

[6]



Simulated data



[5] – OECD Regional eXplorer – M. JERN - <http://stats.oecd.org/OECDregionalstatistics/>  
[6] – Activity tracker – W. CHANG - <https://winston.shinyapps.io/activity-dashboard/>



# EXPLORATION



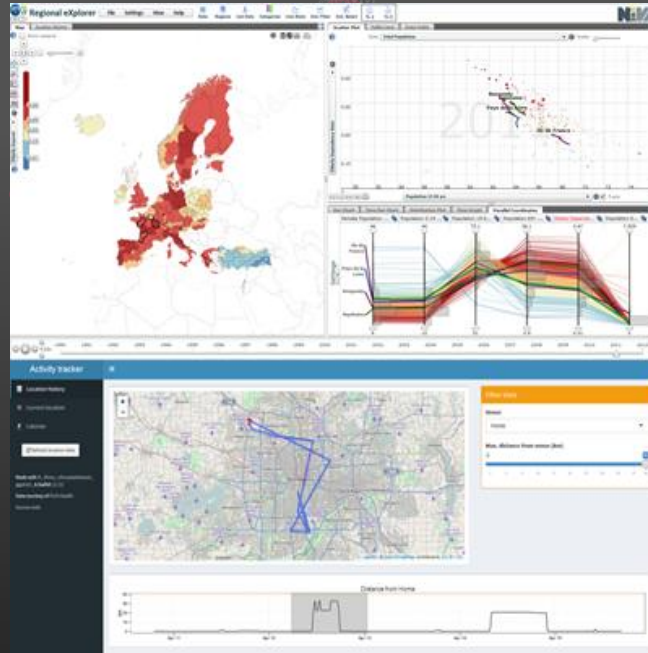
- A PLATFORM FOR VISUAL ANALYSIS OF DATA

GeoVisual Analytics

Linked views

Workflow composer

Interactive filtering



→ MULTIPLYING THE POINTS OF VIEW ON COMPLEX DATA TO EASE-UP THEIR INTERPRETATION

→ DESIGNED FOR ANALYZING SPACE-TIME SIMULATION DATA

# MY PHD PROJECT

## Questioning

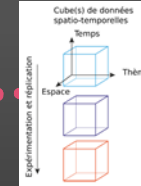


Sources



Confrontation

Confirmation / Refutation



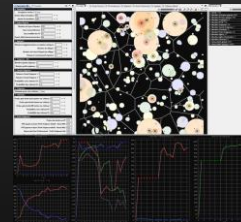
Simulated data

Validation

Simulation



Modelling



Hypotheses

Model

800



1100

THANKS FOR LISTENING

ANY QUESTION ?

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100ans