Agent based models of social dynamics. What for?

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Discussion at CSS 2023

Scott Moss

Rainer Hegselmann

Models for decision support vs abstract models

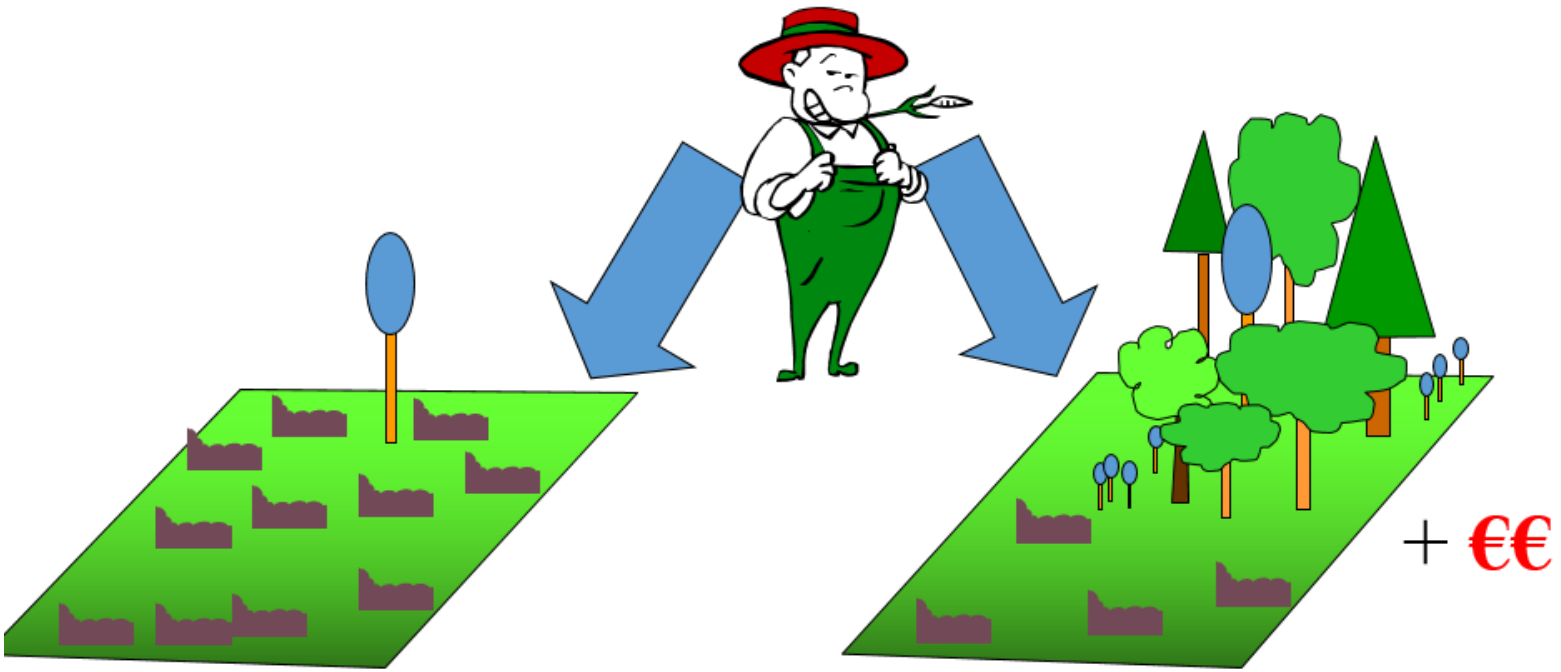
Koblenz ESSA confeerence, 2005

- Dialogues concerning a (possibly) new science
  (Deffuant, Moss, Jager, JASSS 2006).

Temptation of "Realism"

- Temptation of Saint Anthony (Ieronimus Bosh, 1501).

European project IMAGES - 1997-2001



- Modelling the adoption of agri-environmenal measures by European farmers.
- Ultimate goal: policy maker decision support

Multi-disciplinary team

Nigel Gilbert

Edmund Chattoe

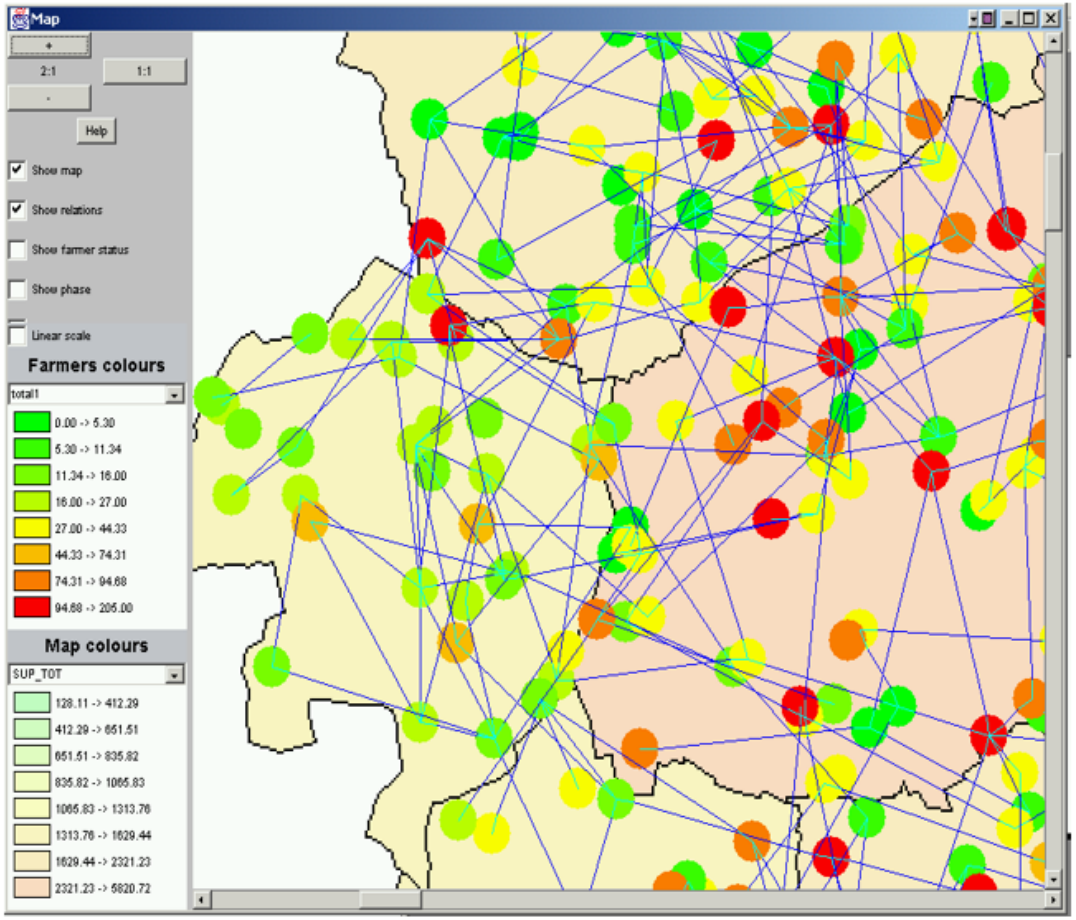
Gérard Weisbuch

Fredéric Amblard

Sylvie Huet

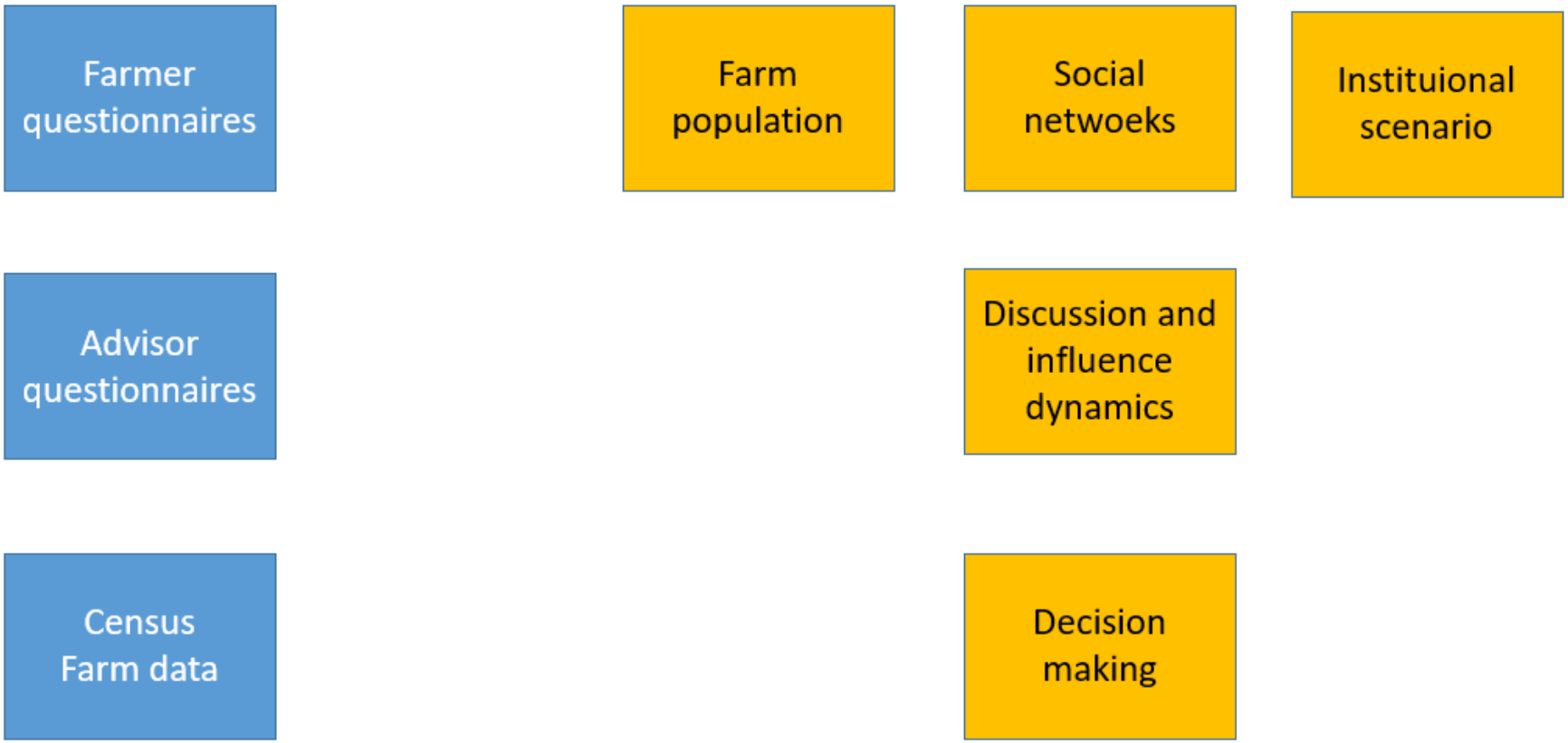
Sarah Skerratt

Agent based model



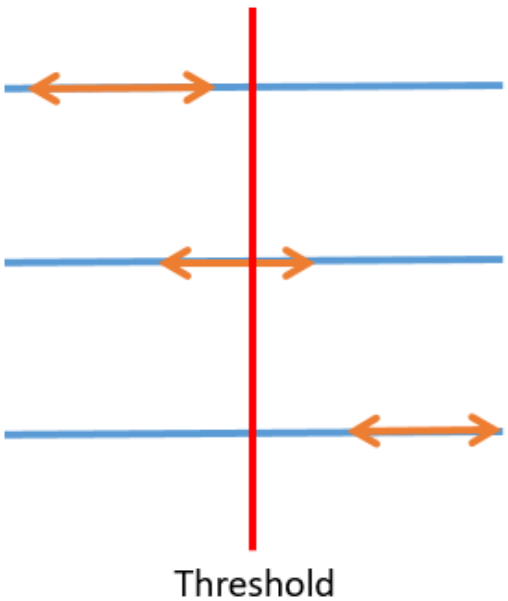
- Farmer agents
- Interacting on social networks

Multiple data sources and models



- Case studies in UK, France, Italy.

Decision process



Not interested

Discusses

Uncertain

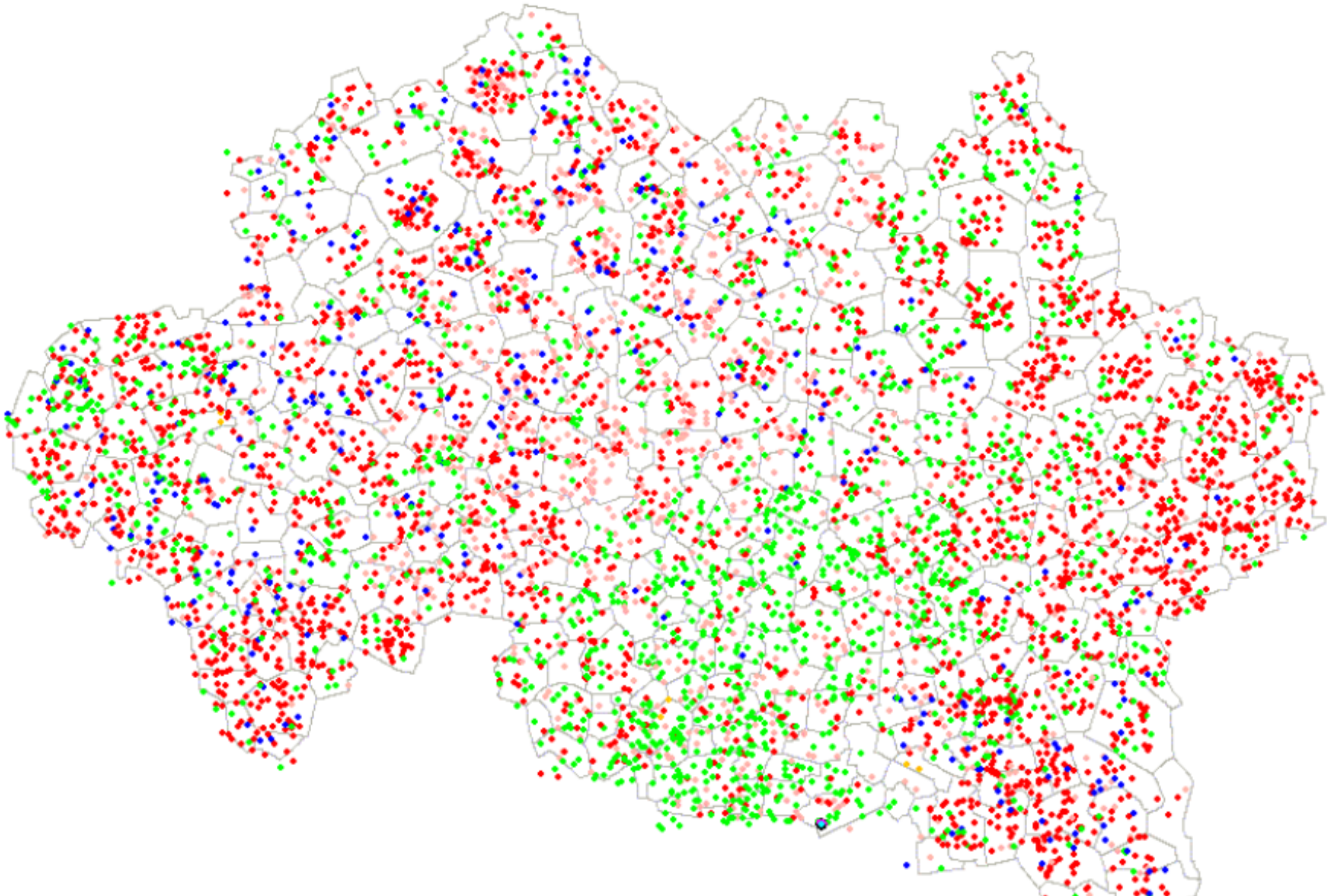
Discusses
Asks information, goes to meetings
Evaluates effect if information

Interested

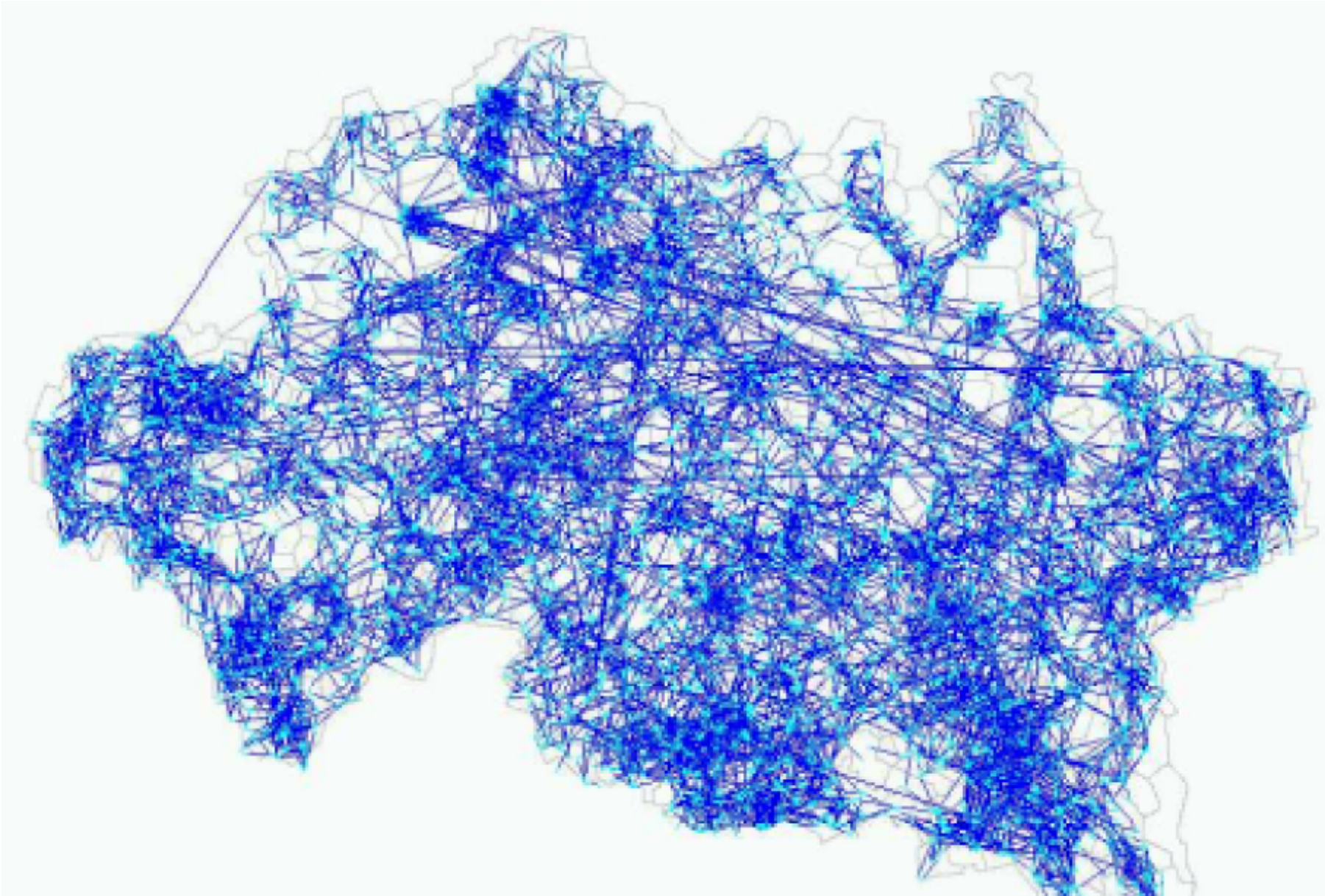
Same +
Requests visit if information
Adopts if interested long enough

Deffuant, Huet, Amblard, AJS, 2005

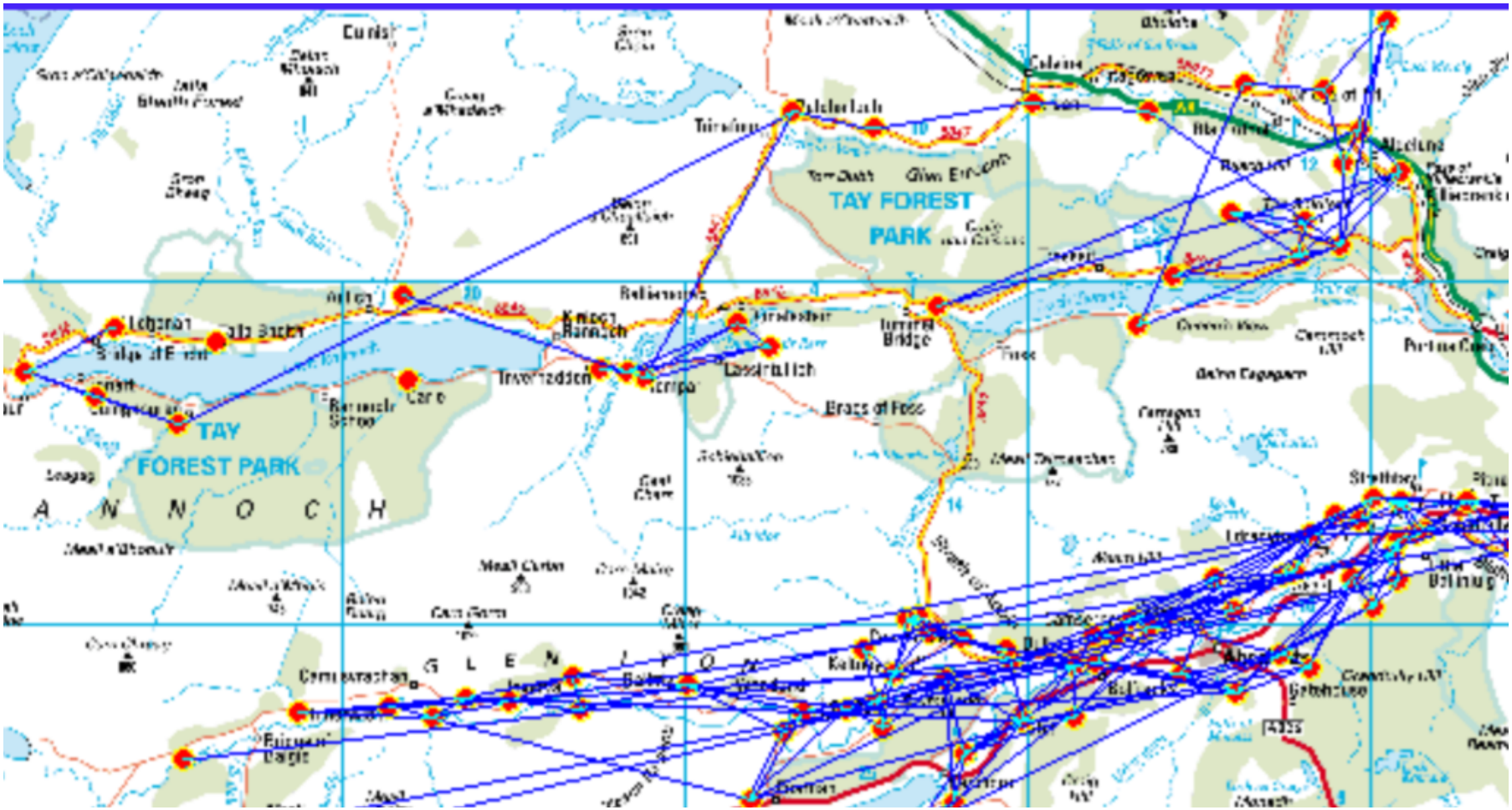
Farms in Allier département (France)



Social network in Allier département (France)

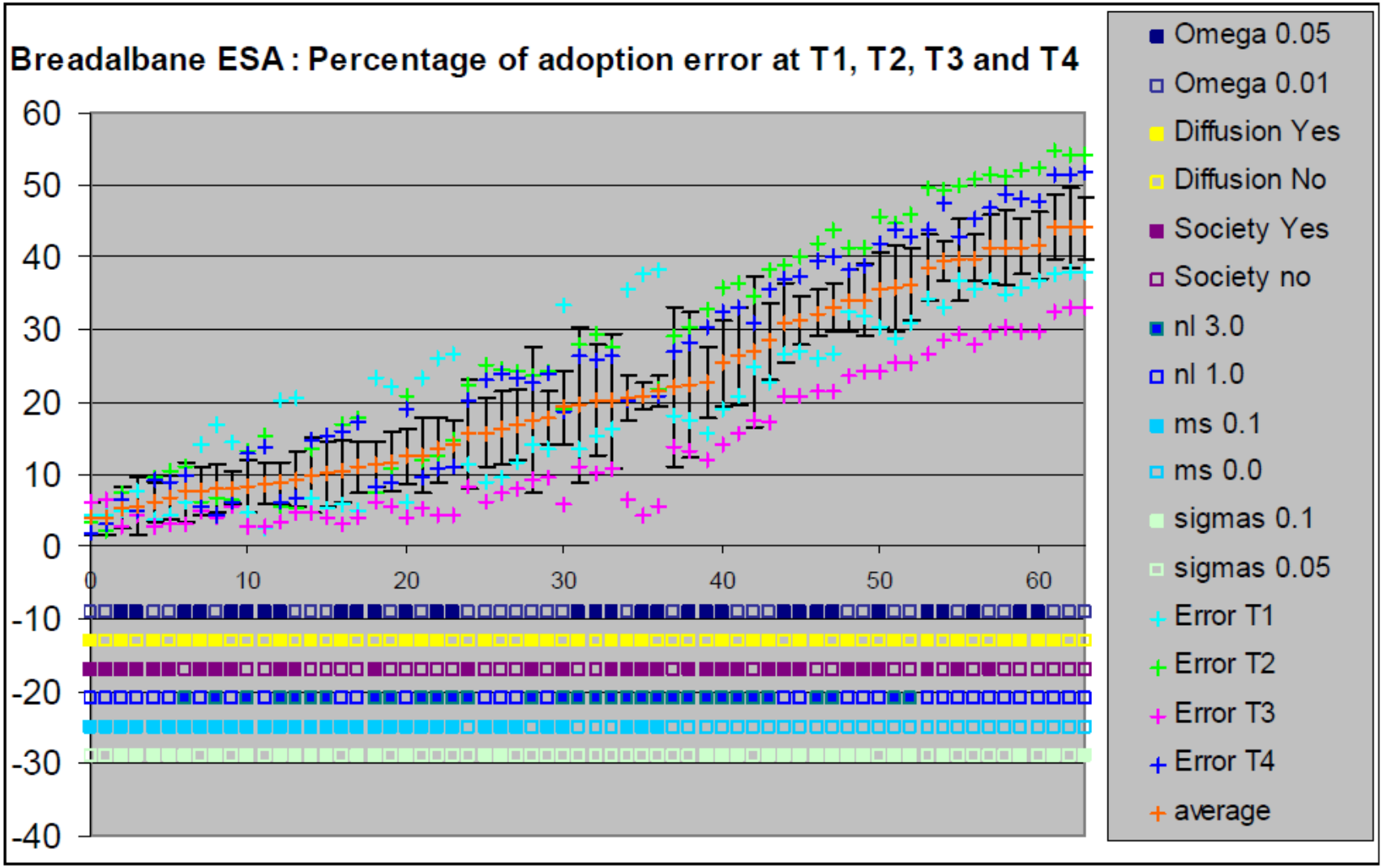


Example of Breadalbane ESA (Scotland)

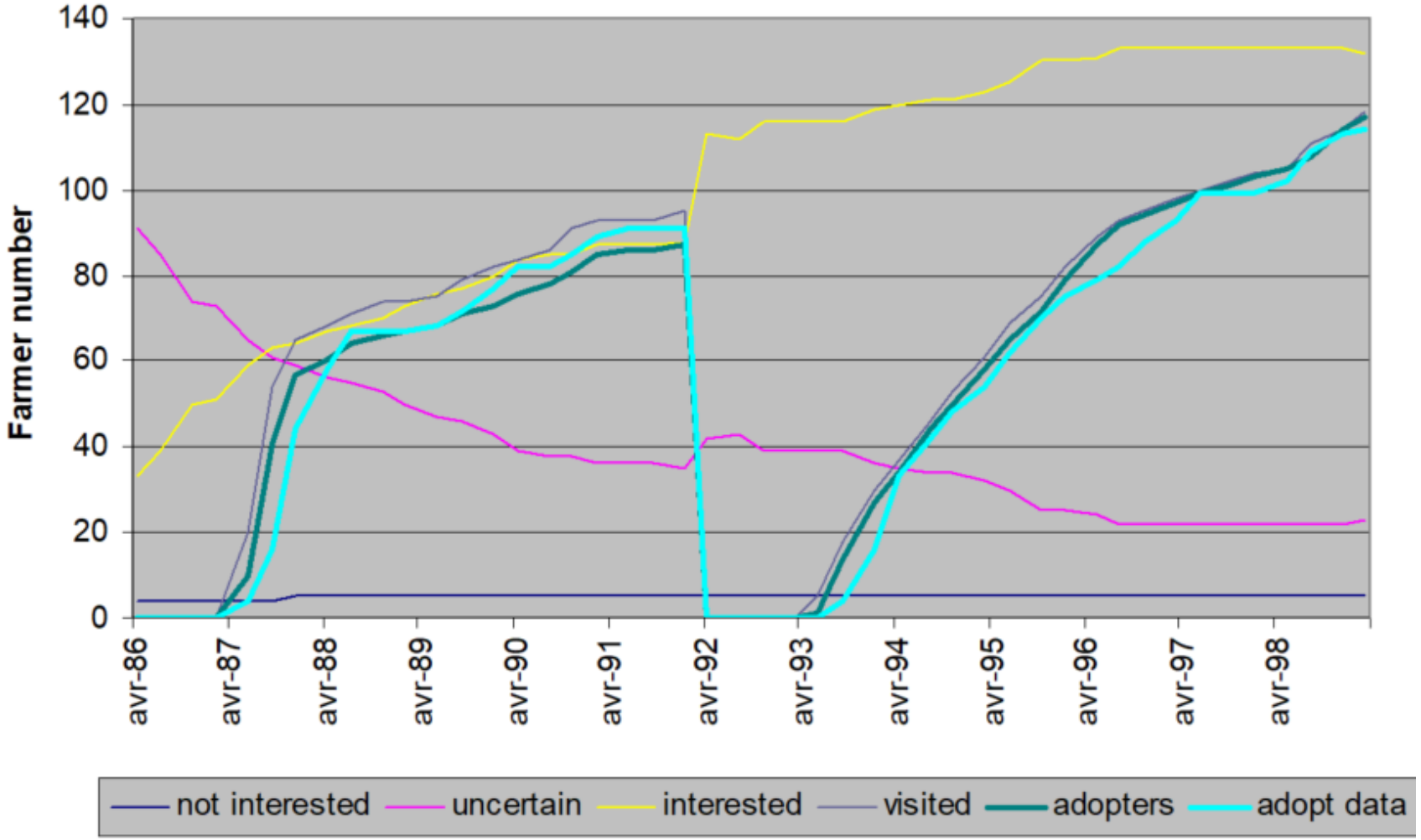


- First period of adoption (1986 -1992)
- Second period of adoption (1993 - 1998), with same agri-environmental measure.

Breadalbane model analysis



Breadalbane example of results

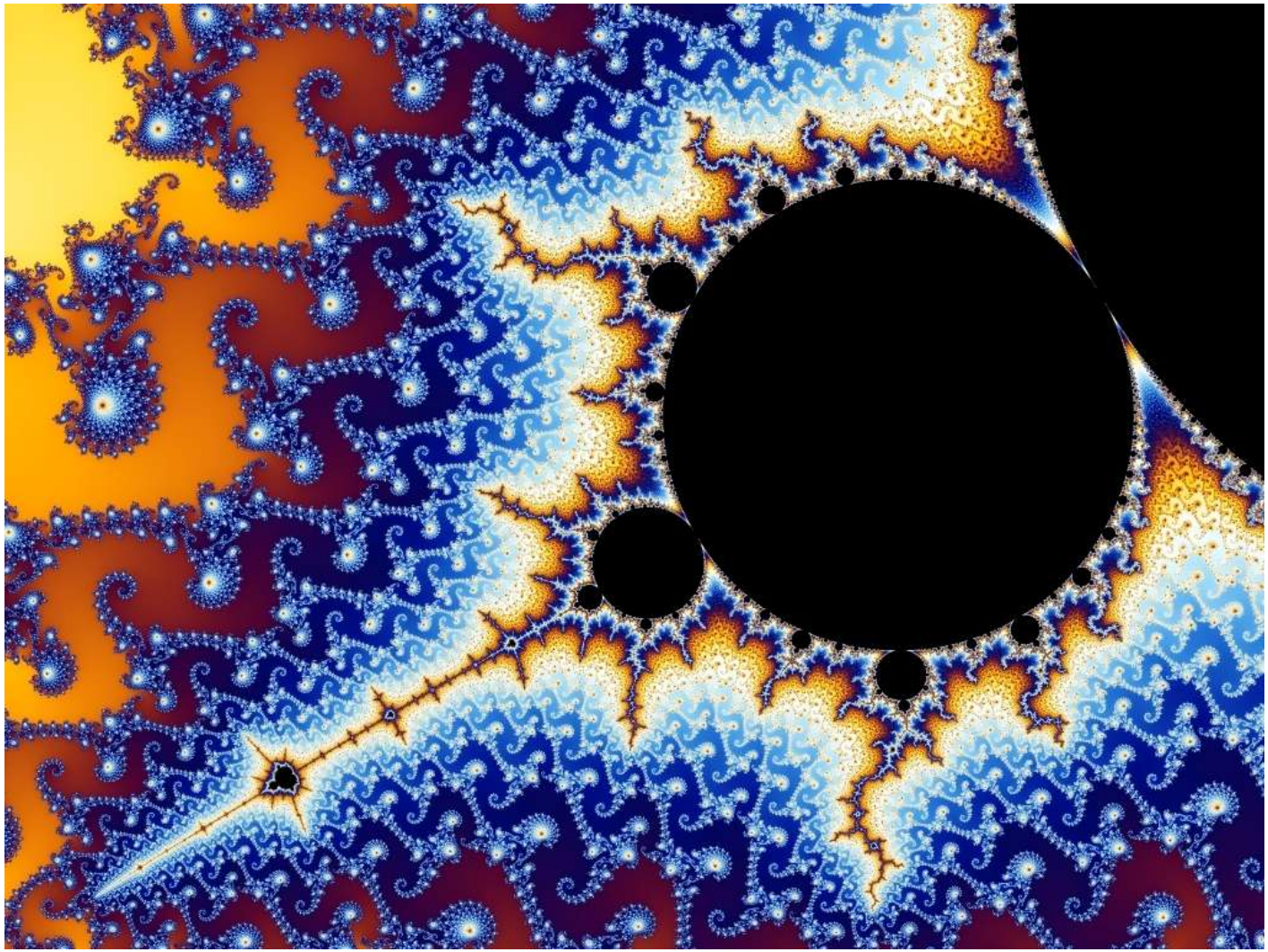


Calibration on first period; Test on second period

Overall

- We developed and tested a lot of models, but:
- **The result is very far from providing operational decision support**
- Many non-checked assumptions;
- Model relies on huge amount of data and expertise for each case study.

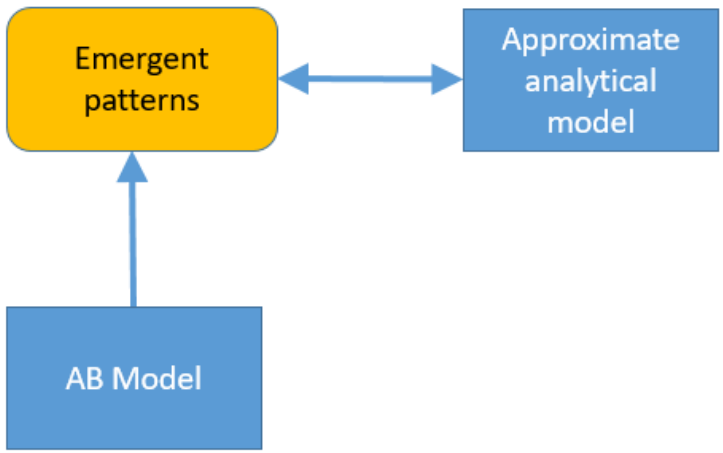
Abstract models: Chasing emergent phenomena



Mandelbrot set

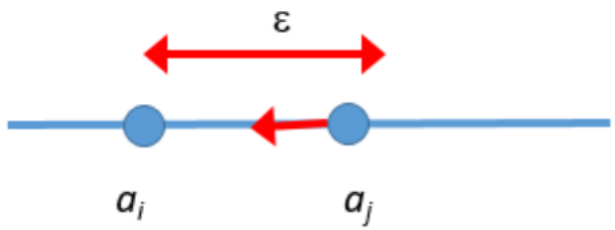
General approach

- Explore the AB model by simulations and identify emergent patterns
- Derive an analytical model of the agent model helping to explain emergent patterns (model of the model)



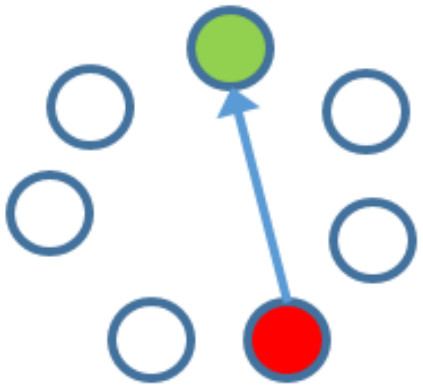
Bounded confidence model of opinion dynamics

- Opinions attract each other if they are not too far (confidence bound).
- Model of confirmation bias (social judgement theory)

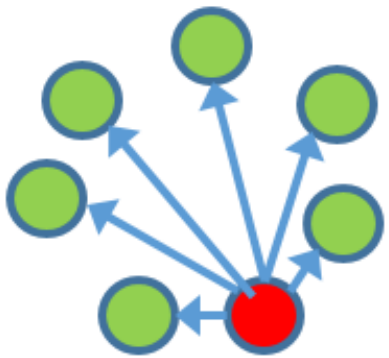


Variants of bounded confidence model

- Interactions by random pairs of agents (DW version)
  (Deffuant et al., ACS 2000, Weisbuch et al., Complexity 2002)



- Interactions with all neighbours (HK version)
  (Hegselmann and Krause, JASSS 2002)



Emergence of opinion clusters

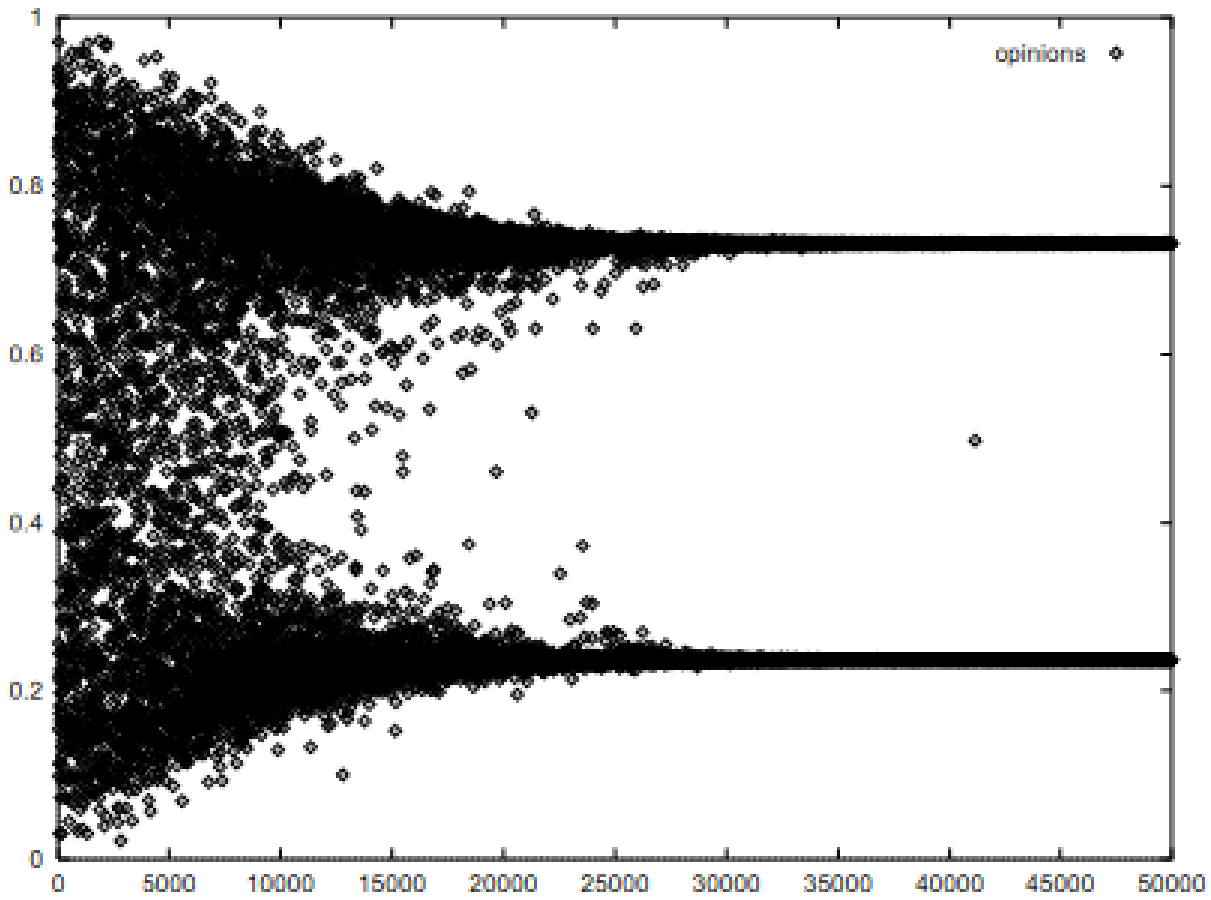
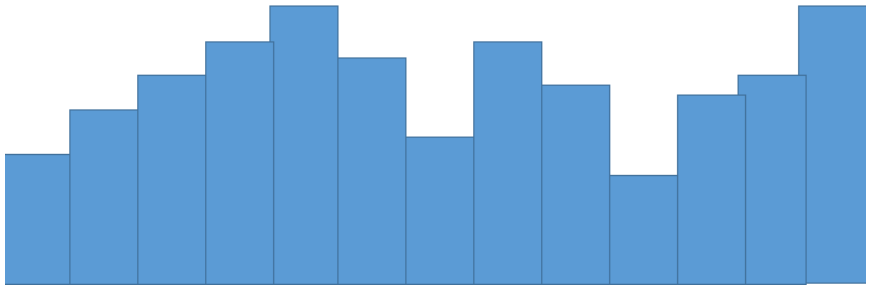


Figure 2. *Time chart of opinions* ($d = 0.2 \quad \mu = 0.5 \quad N = 1000$). *One time unit corresponds to sampling 1000 pairs of agents.*

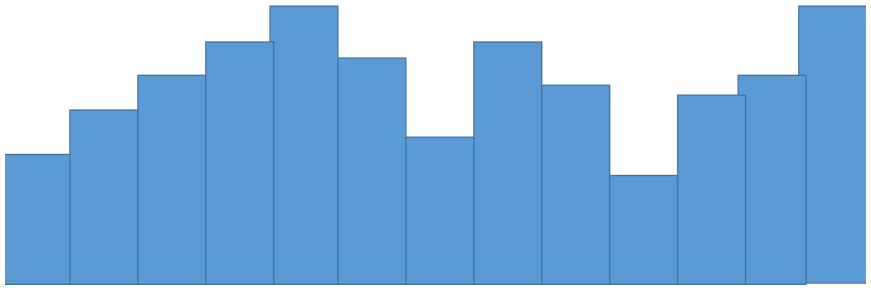
From agents to probability distributions

Initial distribution

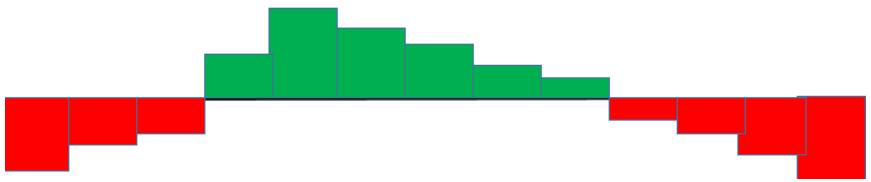


From agents to probability distributions

Initial distribution

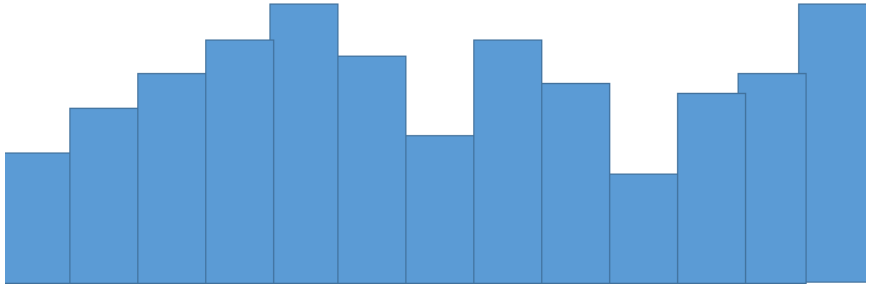


Change



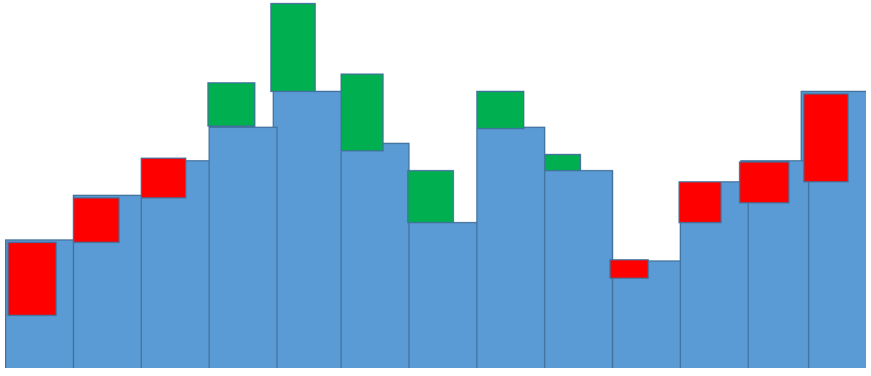
From agents to probability distributions

Initial distribution



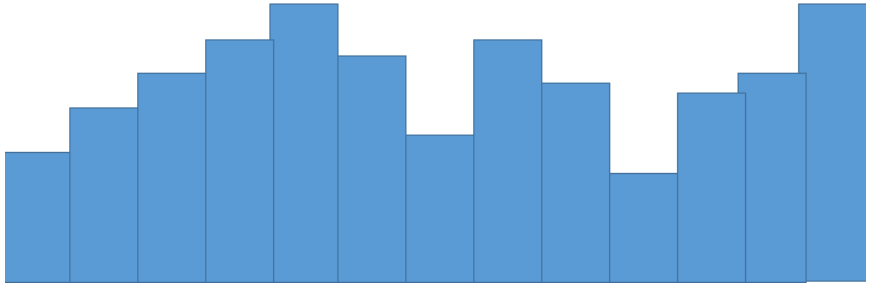
Change

New distribution



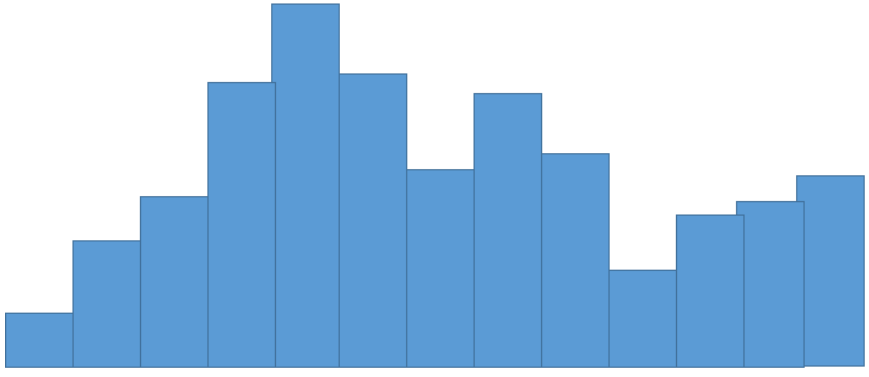
From agents to probability distributions

Initial distribution

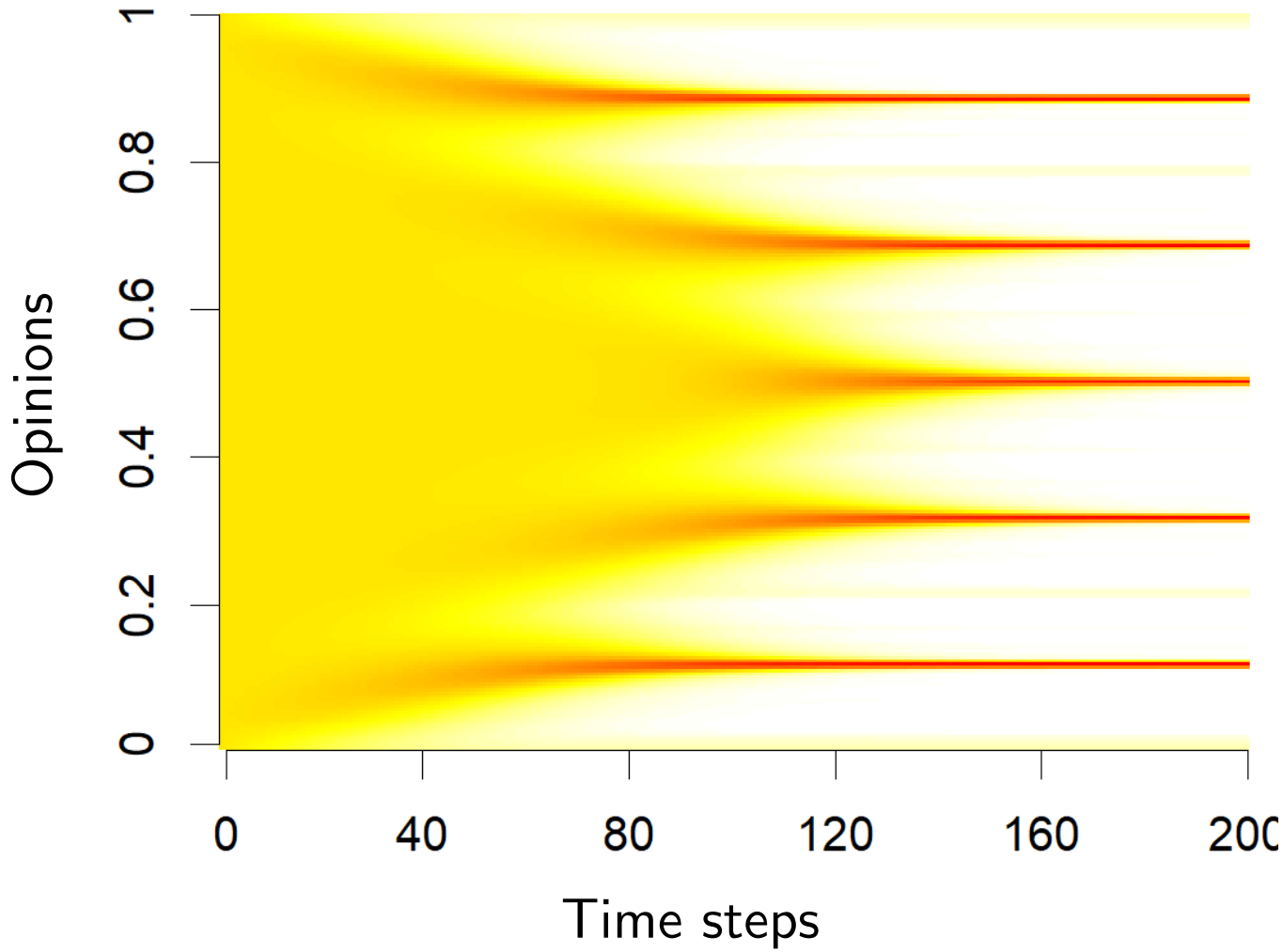


Change

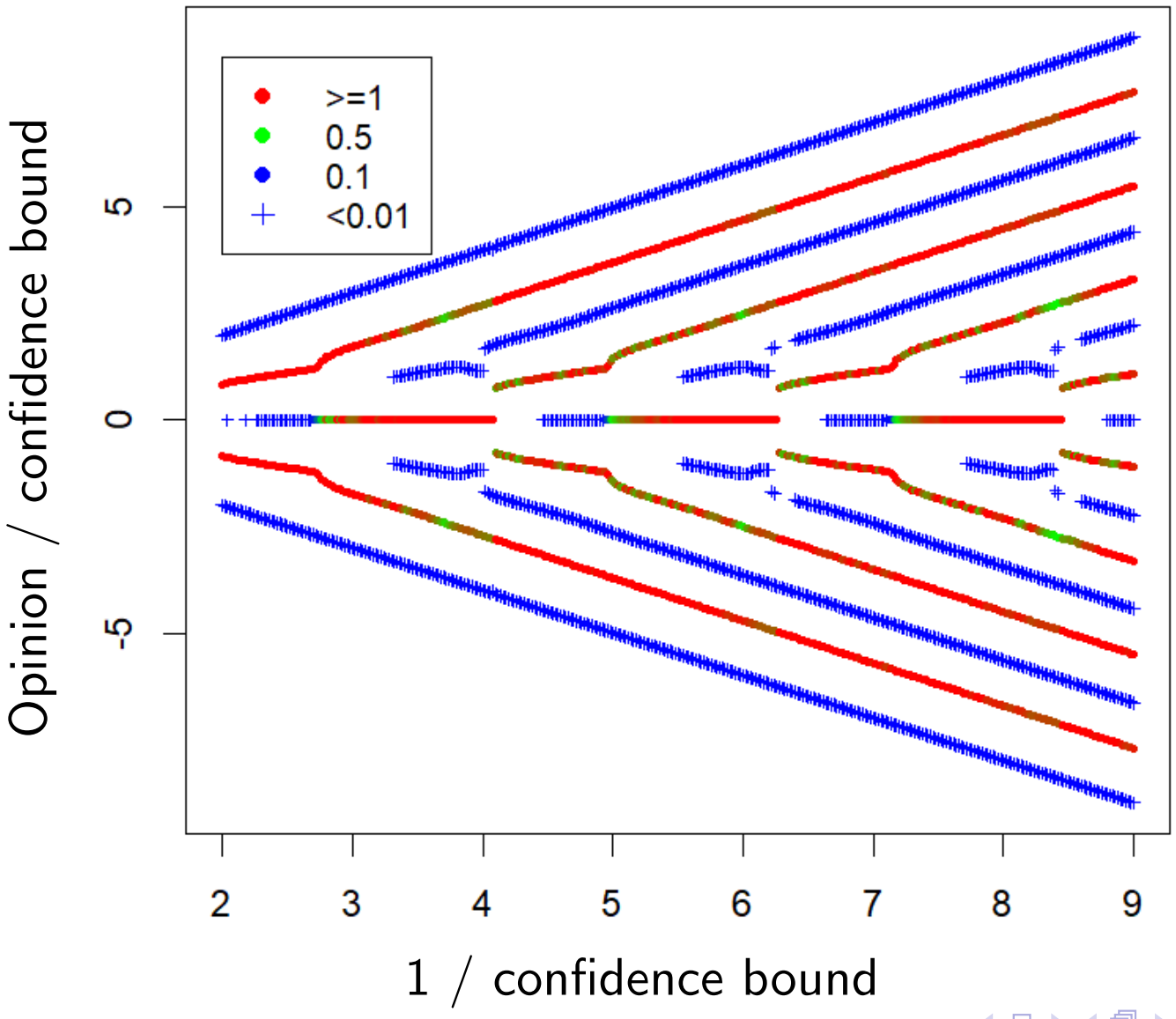
New distribution



Example of results for pair interactions version (DW)

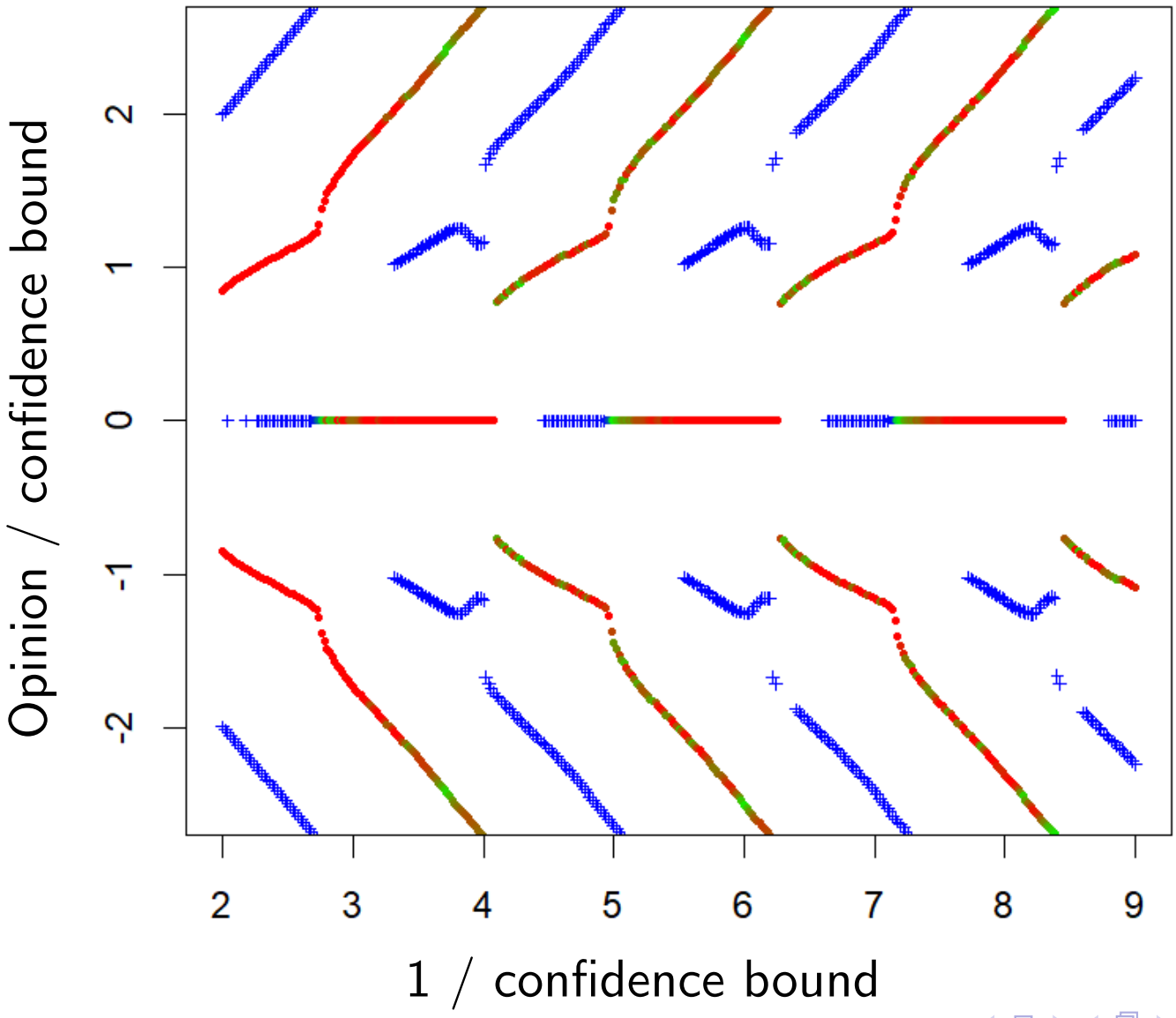


Position of clusters for pair interactions version (DW)



Ben Naim et al., Physica D, 2003.

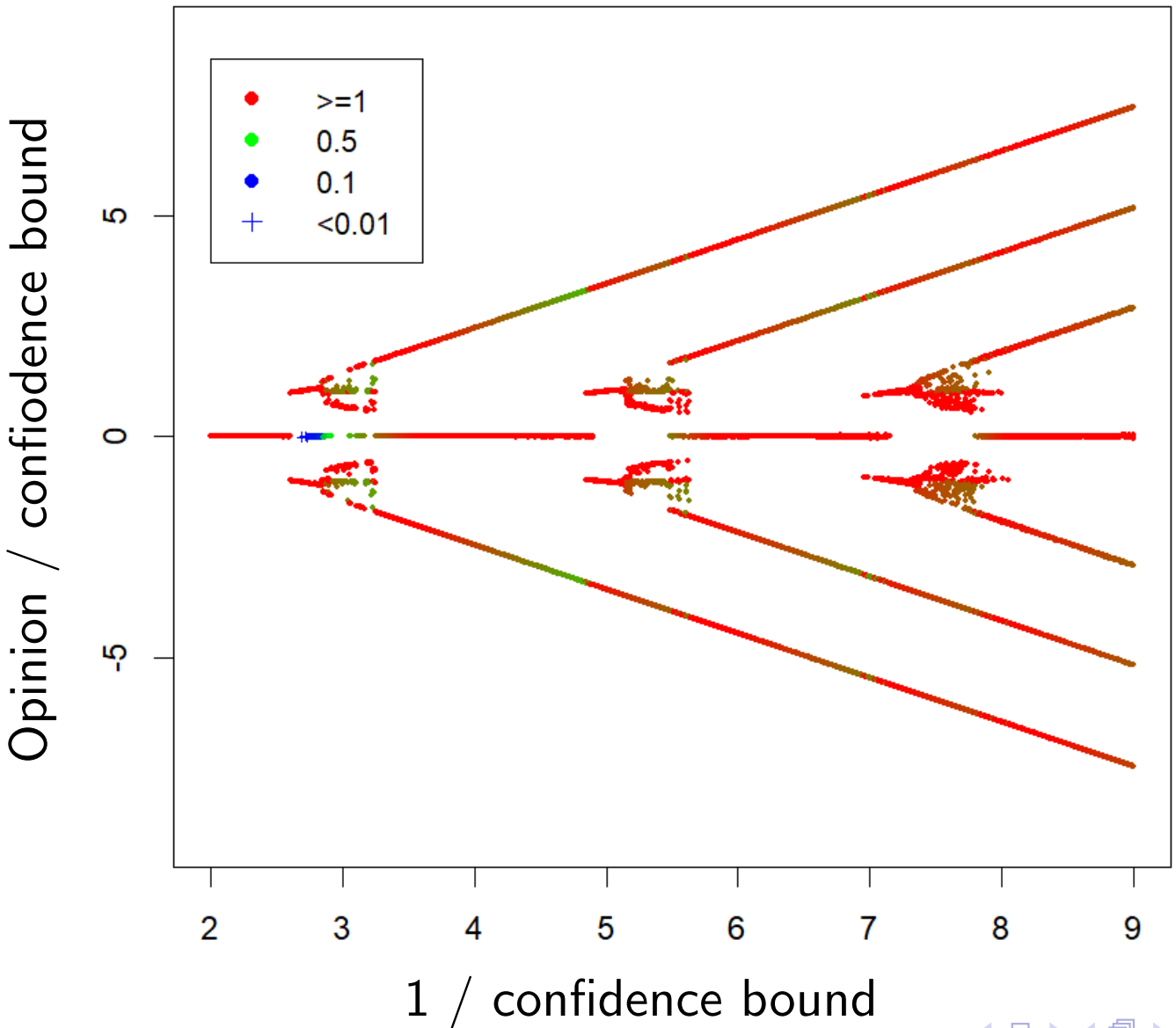
Details



Periodicity !

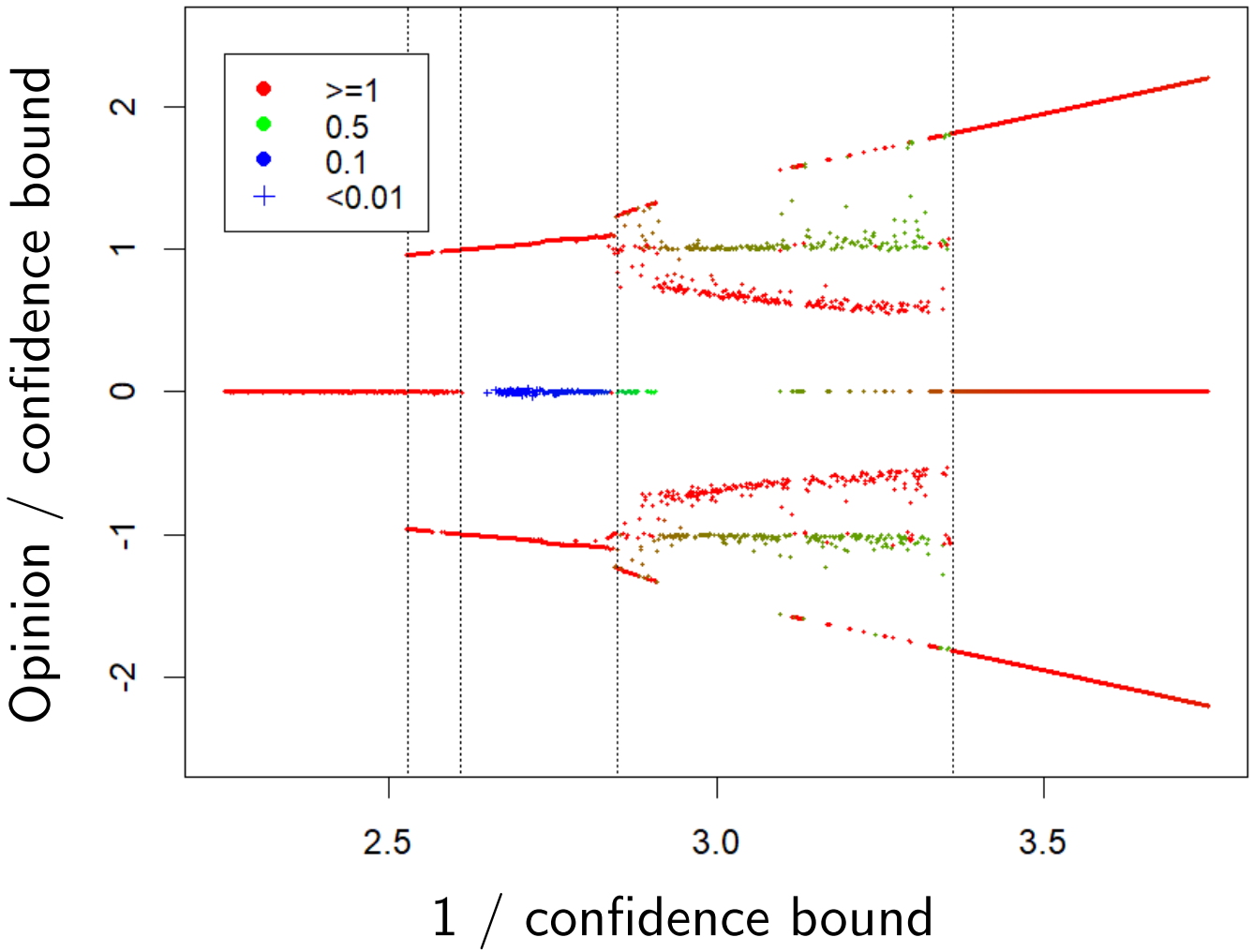
Ben Naim et al., Physica D, 2003.

Position of clusters for all neighbours interactions (HK)



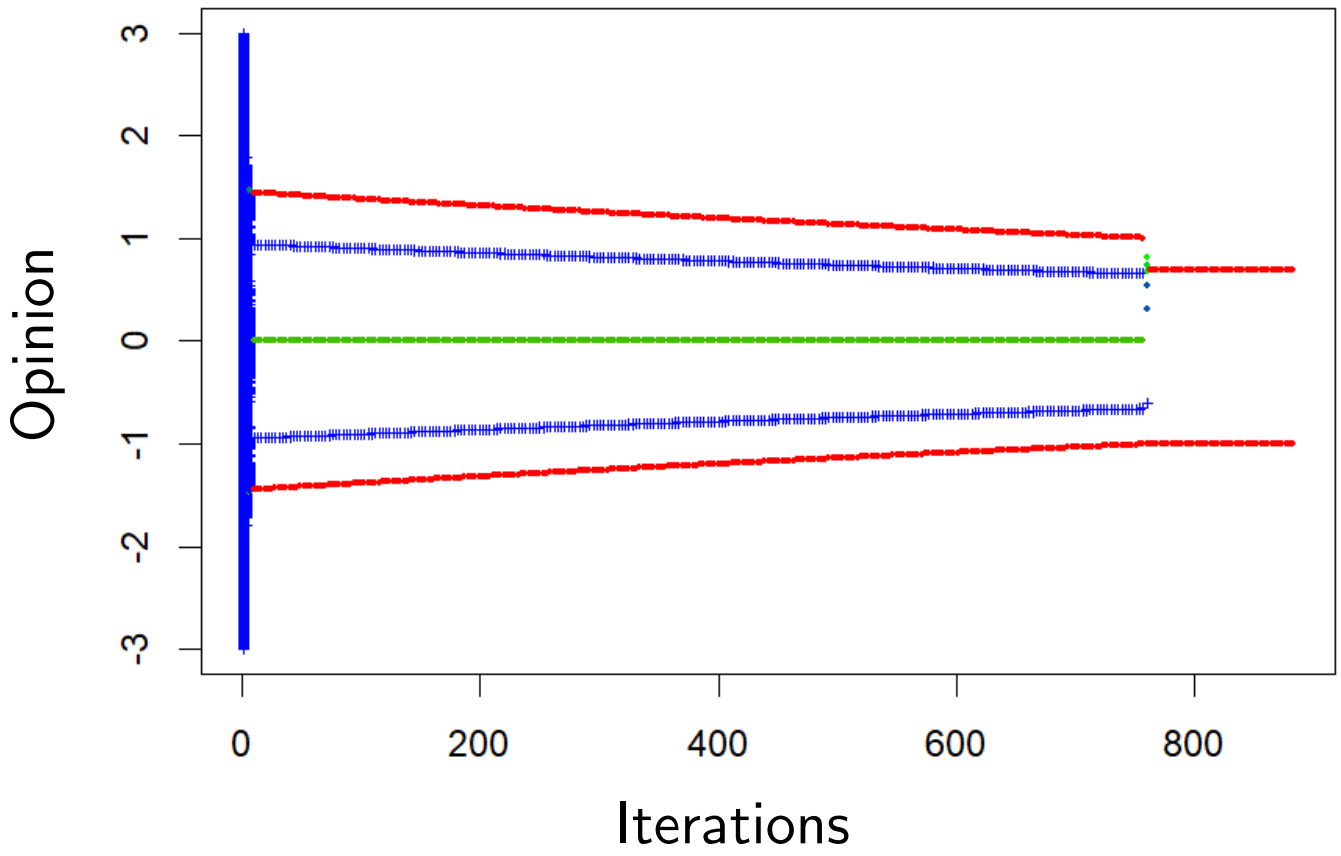
Deffuant, Physics, 2024. (see also Lorenz, Int. Journ. Mod. Physics, 2007)

First transition details



Deffuant, Physics, 2024.

Minor clusters create metastable states

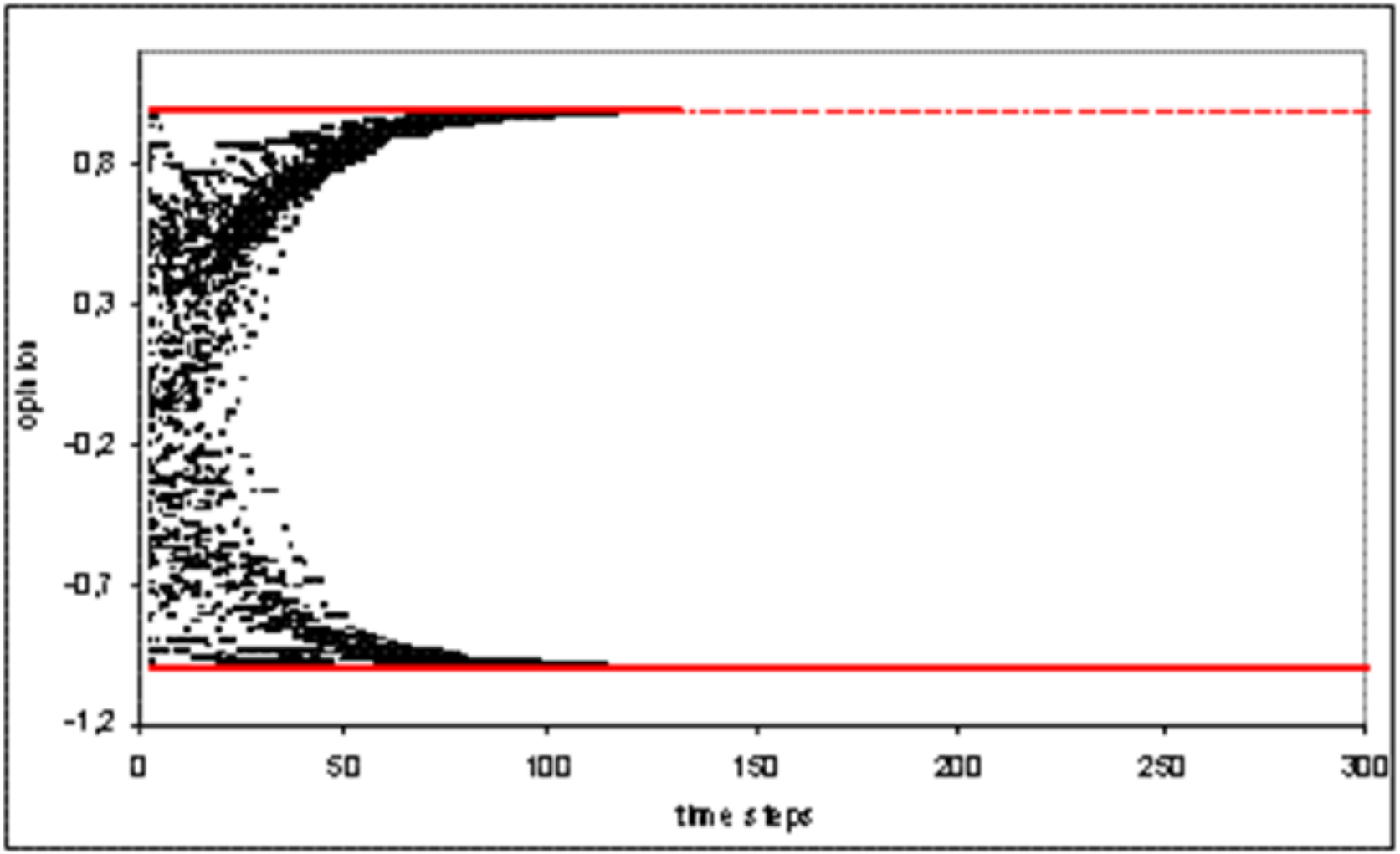


Initialisation with extremists

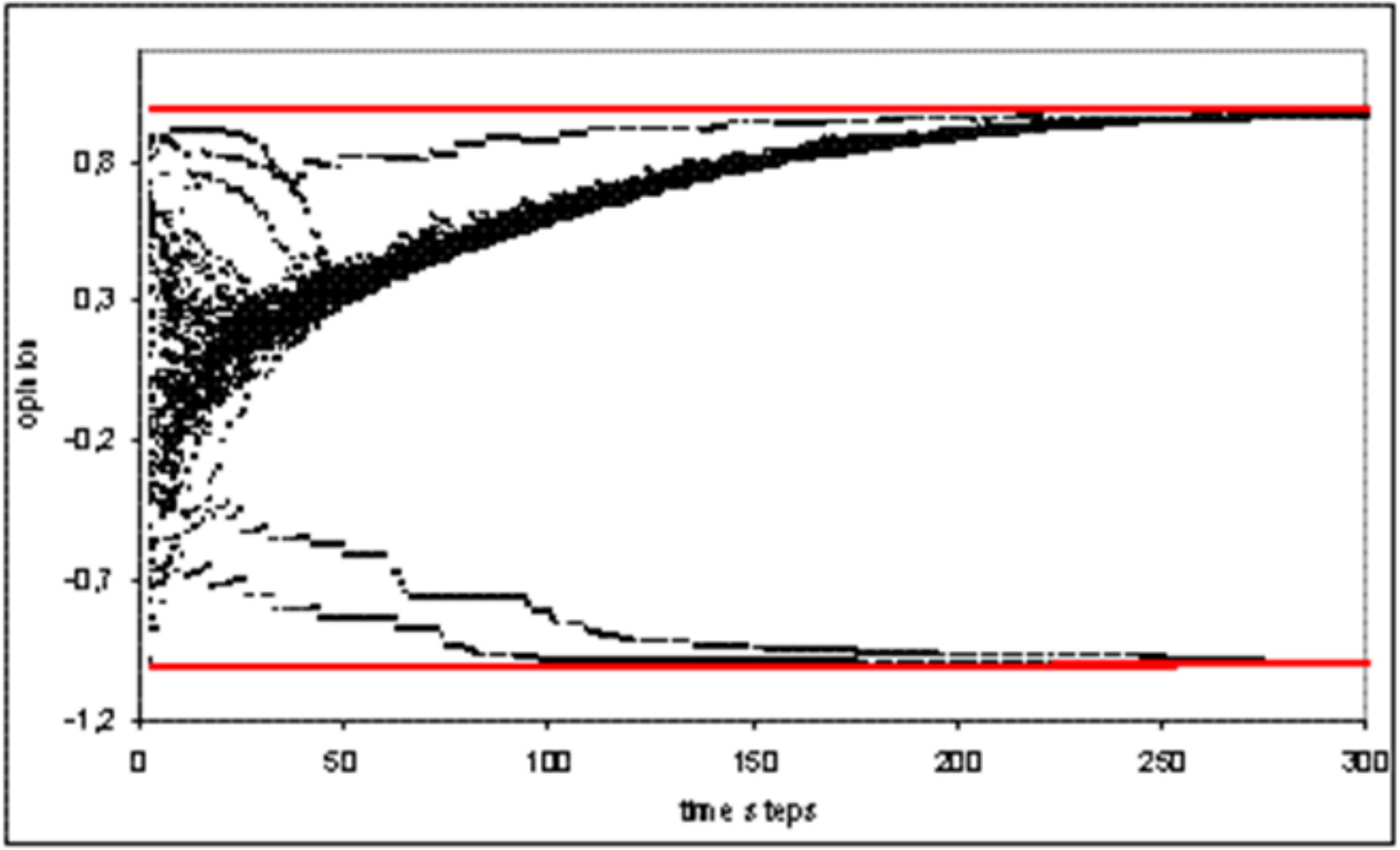
- Moderate agents are initialised with uniform opinion and confidence bound
- Extremist agents have opinion +1 or -1 and very small confidence bound
- During interactions, agents also modify their confidence bound

Deffuant et al. JASSS, 2002

Double extreme convergence

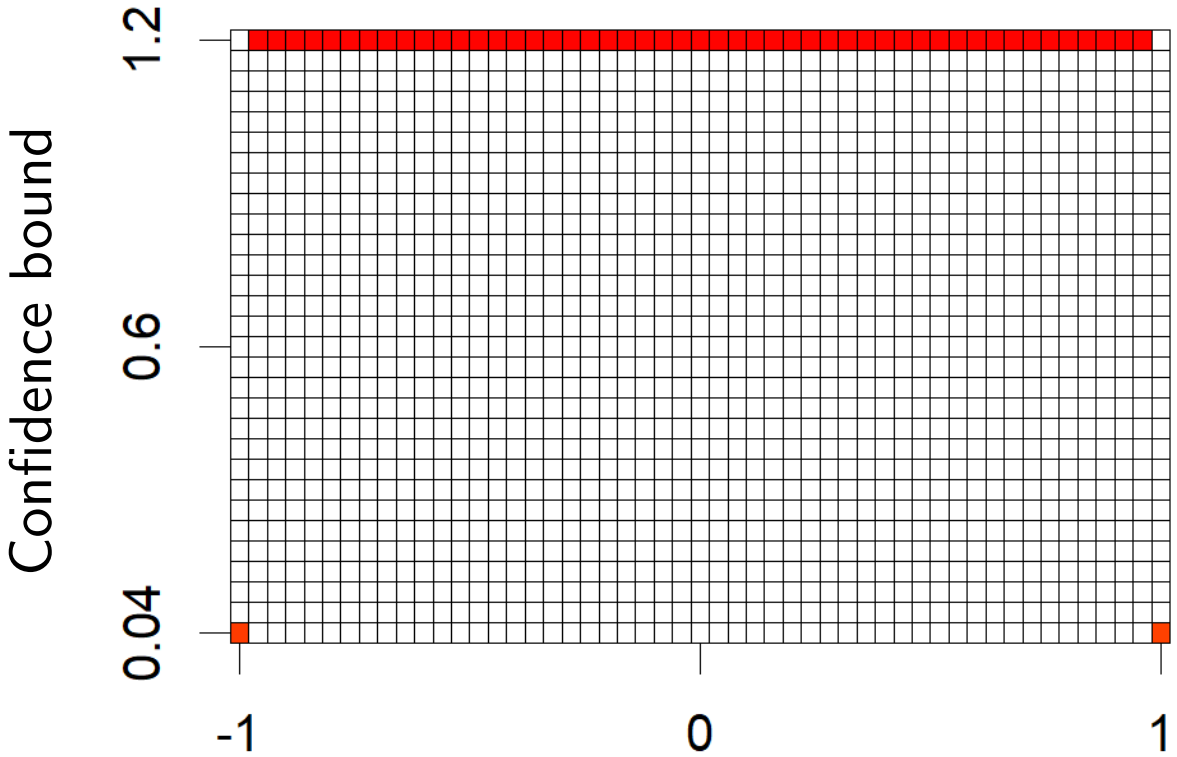


Single extreme convergence



Deffuant et al. JASSS, 2002

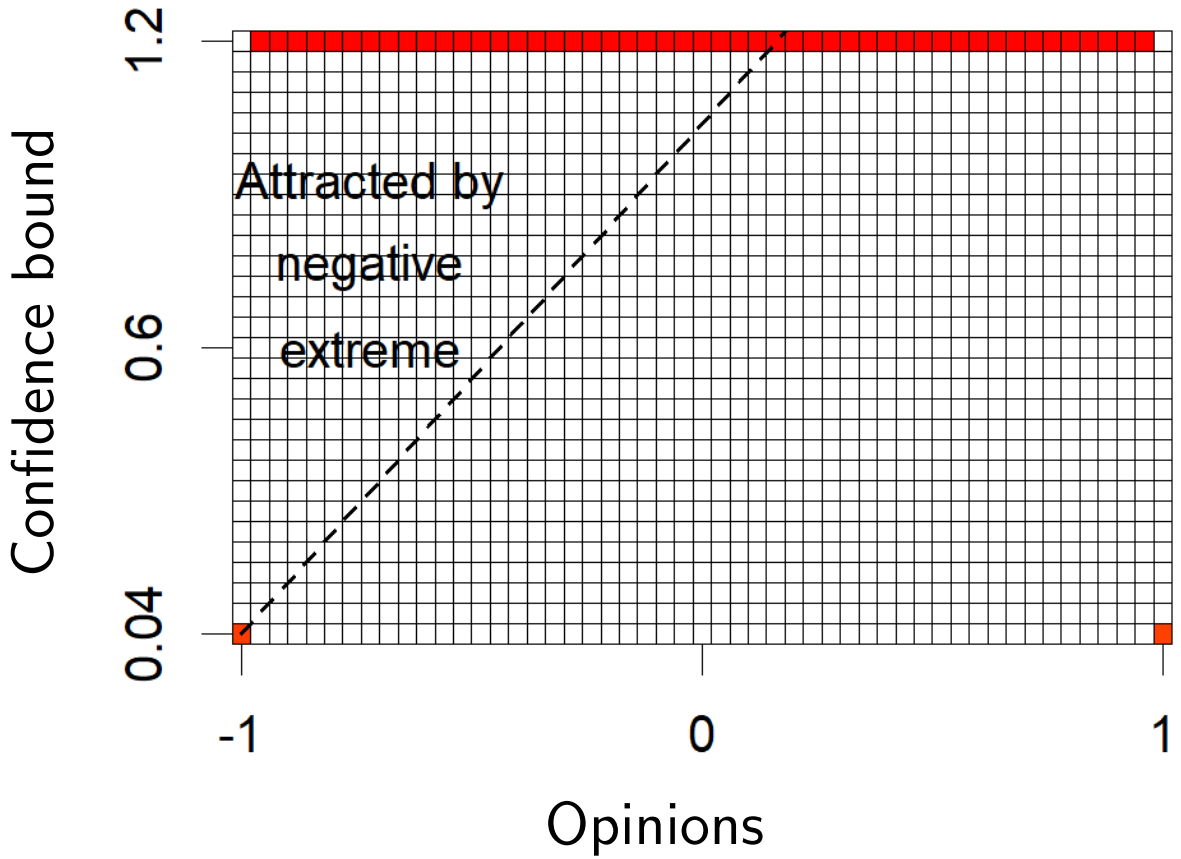
Studying single convergence with distribution models



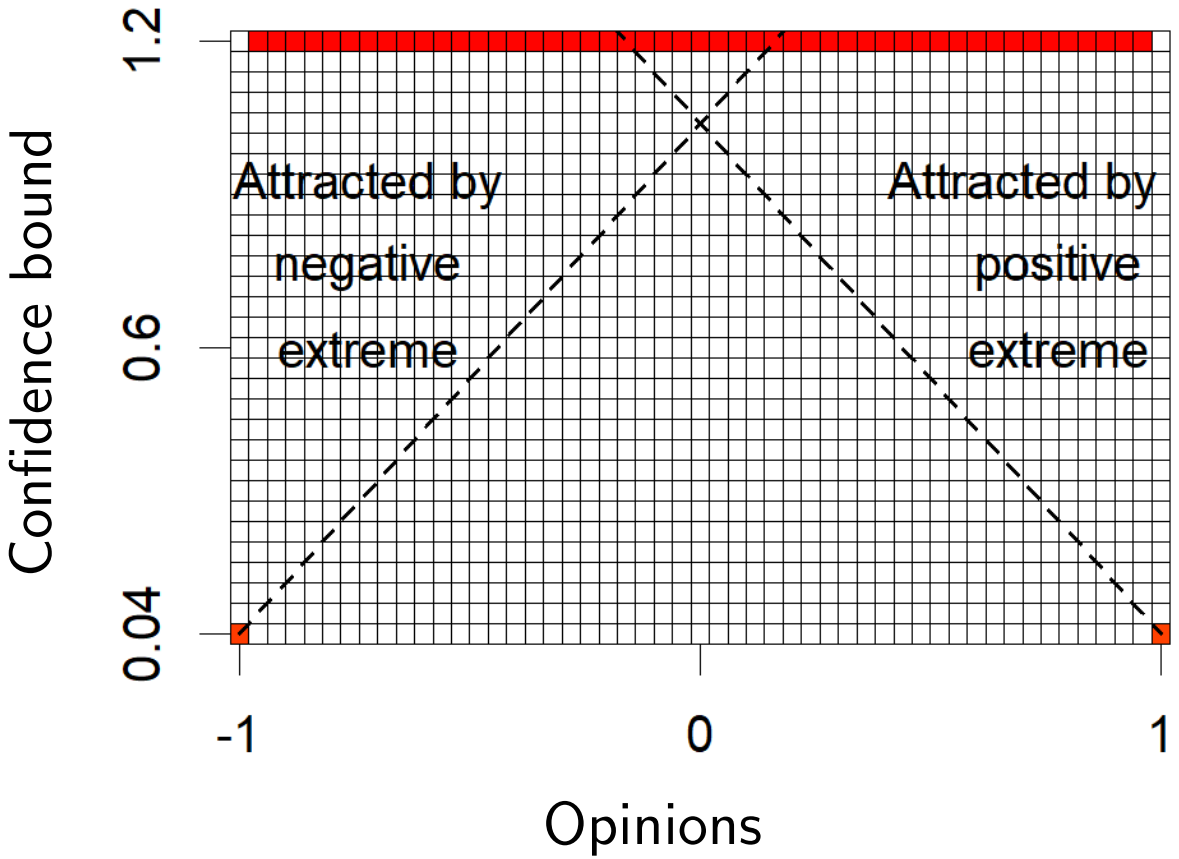
The rules of interactions apply to each cell of the grid and the distribution evolves.

(Deffuant and Weisbuch 2008).

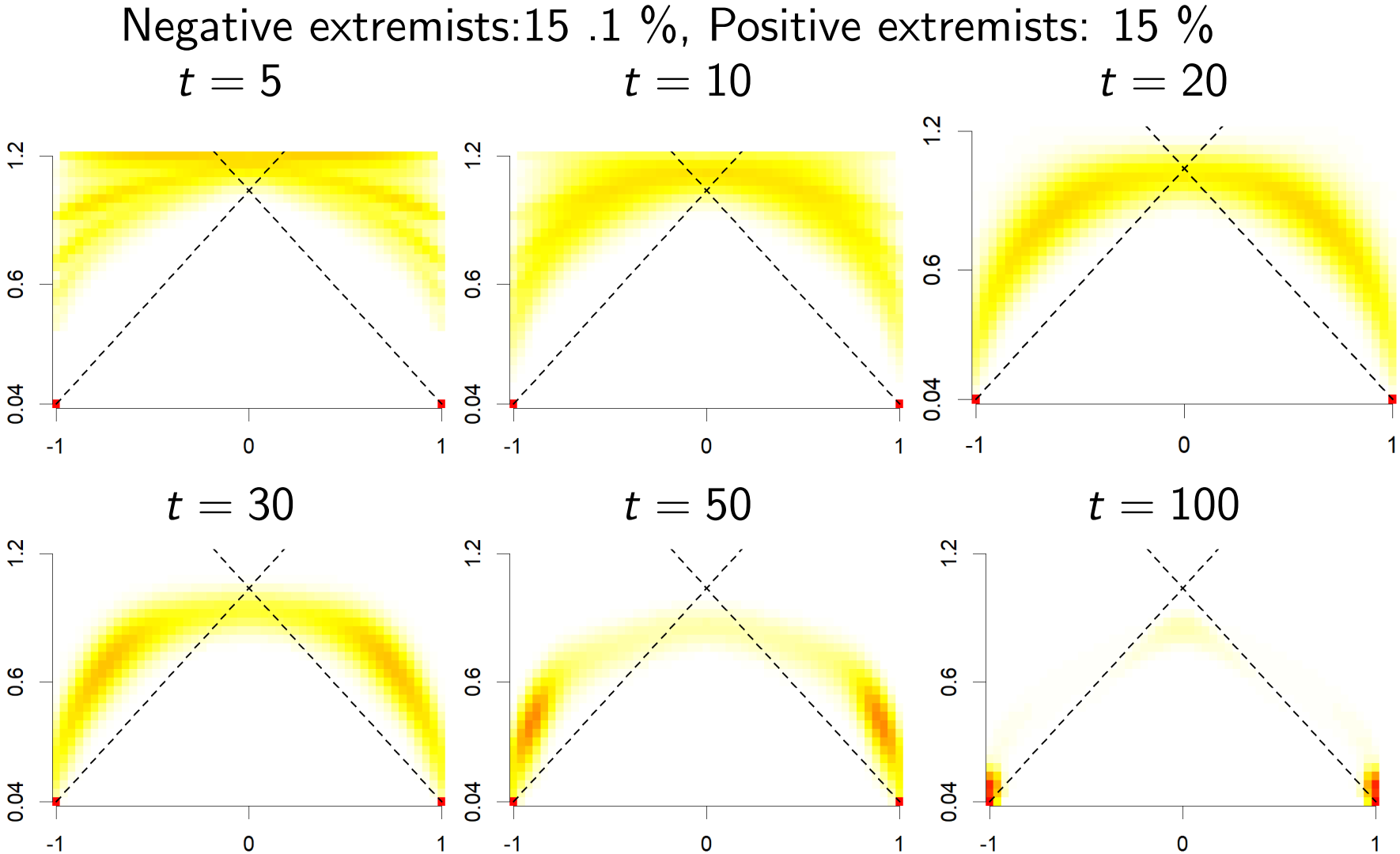
Zones of influence



Zones of influence

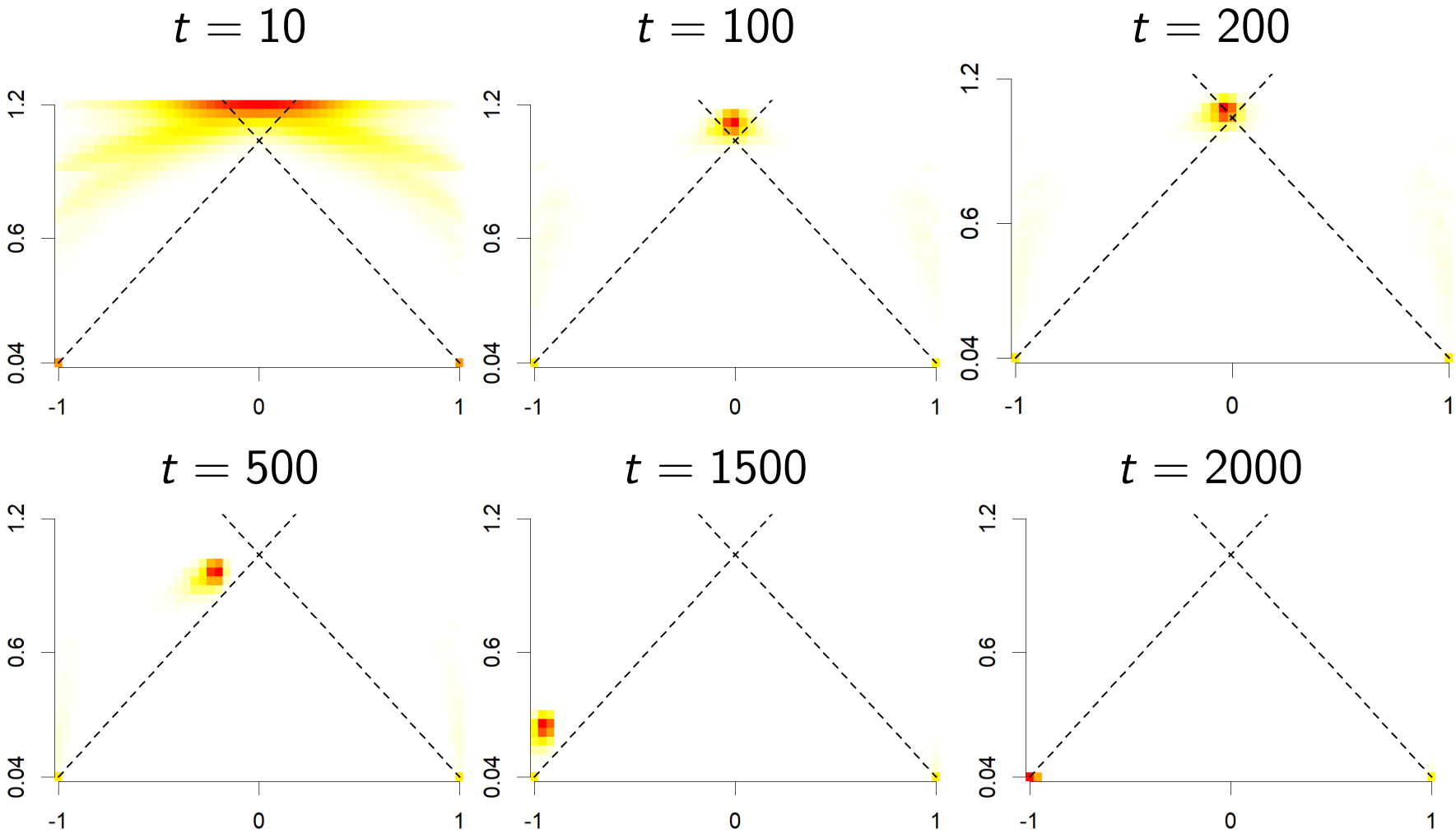


Double extreme convergence



Single extreme convergence

Negative extremists: 1.1 %, Positive extremists: 1 %

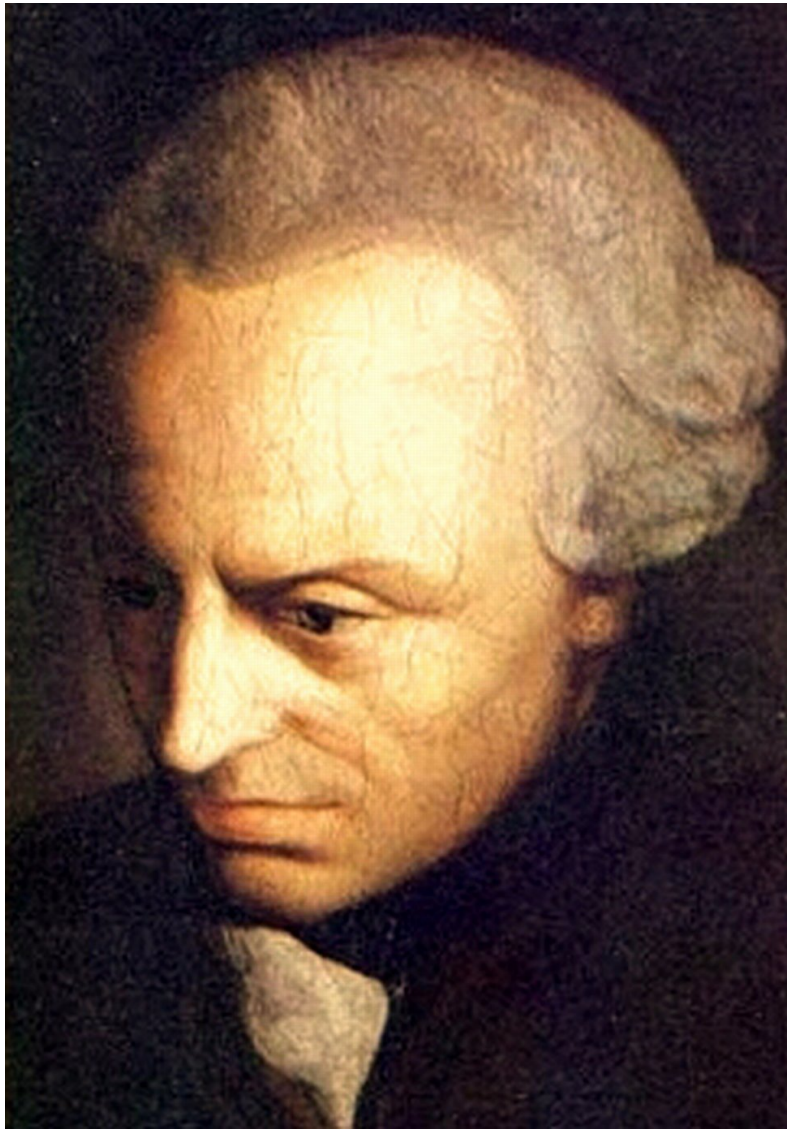


Discussion

- Many variants since first papers: distribution of bounds, influence functions, addition of noise, networks...
- Some well established theoretical results
- Sometimes far from social interpretations

Models for experiments

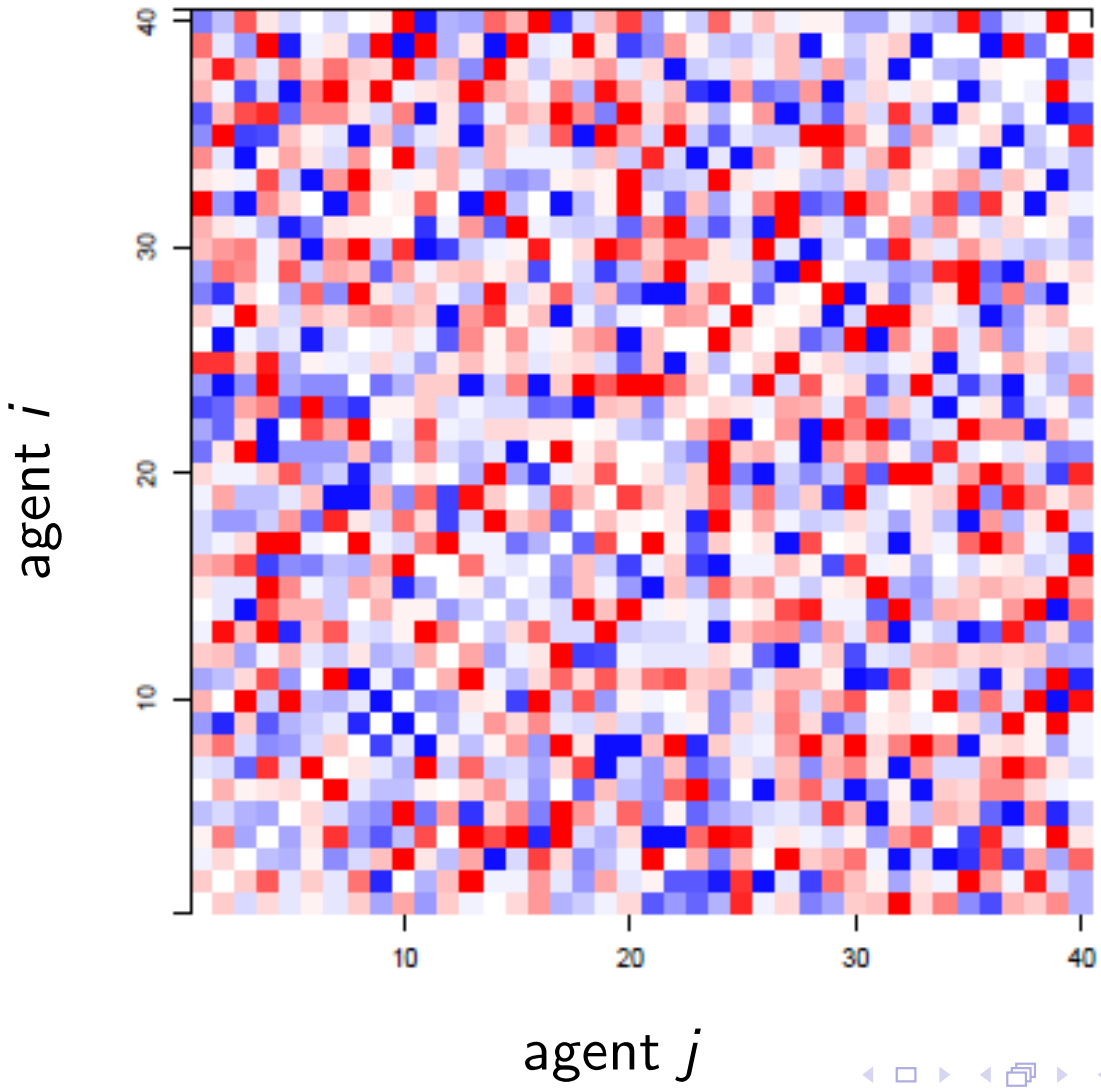
E. Kant



"He experiments [..], in order to draw knowledge from nature, [..] like a judge who interrogates a witness making him answer the questions he asks."

Model of agents having opinions about each other

- Agent i has an opinion a_{ij} about all the agents j



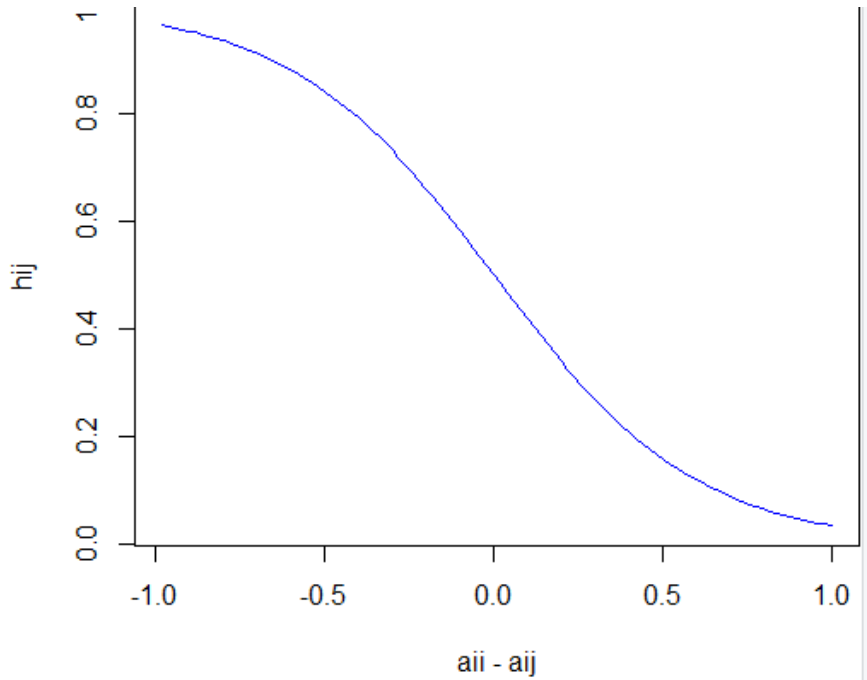
Model dynamics: noisy attractive influence

Agents encounter by pairs and discuss about each other:

$$a_{ii}(t+1) = a_{ii}(t) + h_{ij}(a_{ji}(t) - a_{ii}(t) + \theta(t))$$

- $\theta(t)$ noise: random number in $[-\delta, \delta]$
- h_{ij}: Influence of j on i:

$$h_{ij} = \frac{1}{1 + exp\left(\frac{a_{ii} - a_{ij}}{\sigma}\right)}$$



- The more i feels superior to j, the closer h_{ij} to 0. The more i feels inferior to j, the closer h_{ij} to 1.

$$a_{ij}(t+1) = a_{ij}(t) + h_{ij}(a_{jj}(t) - a_{ij}(t) + \theta(t))$$

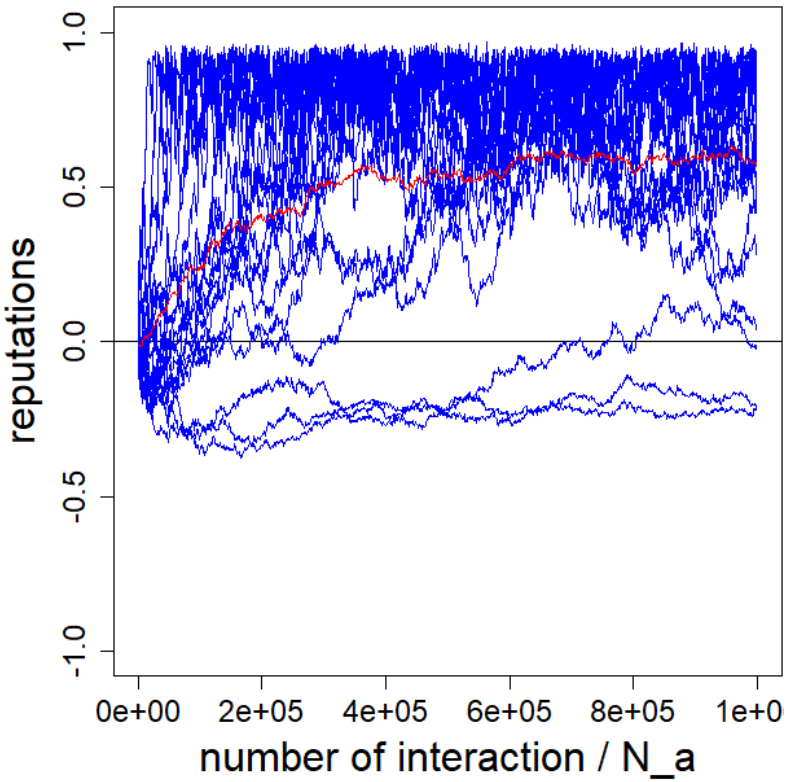
Possibility of gossip

- When agents i and j meet, they talk about each other, modifying their self-opinions and their respective opinions about each other,
- They discuss also about $k \geq 0$ randomly chosen other agents p, and:

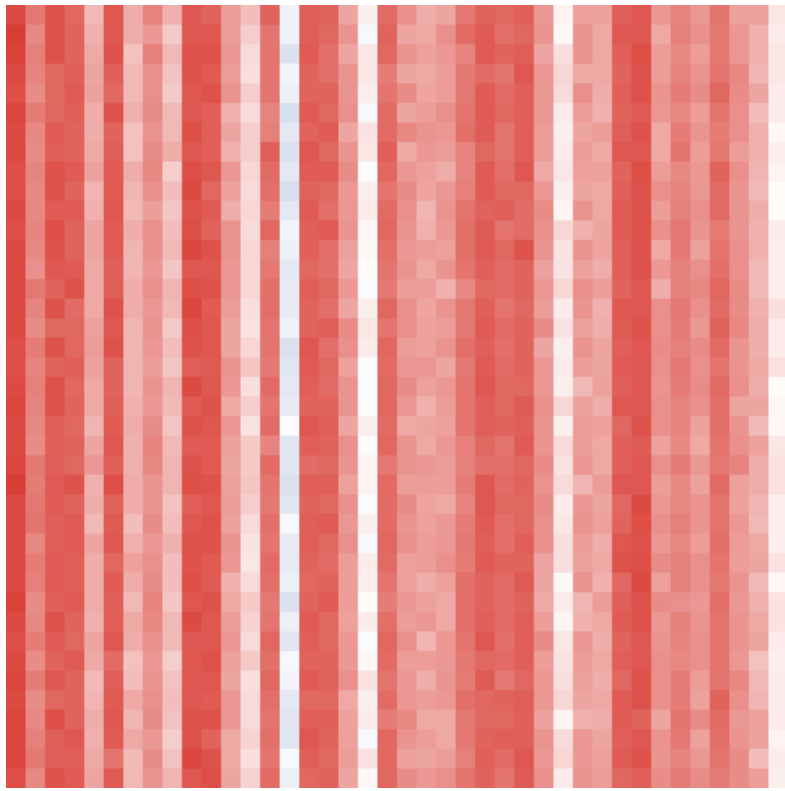
$$a_{ip}(t+1) = a_{ip}(t) + h_{ij}(t)(a_{jp}(t) - a_{ip}(t) + \theta(t))$$
$$a_{jp}(t+1) = a_{jp}(t) + h_{ji}(t)(a_{ip}(t) - a_{jp}(t) + \theta(t))$$

Deffuant, Huet and Carletti al. JASSS, 2013.

Positive drift without gossip ($k = 0$)

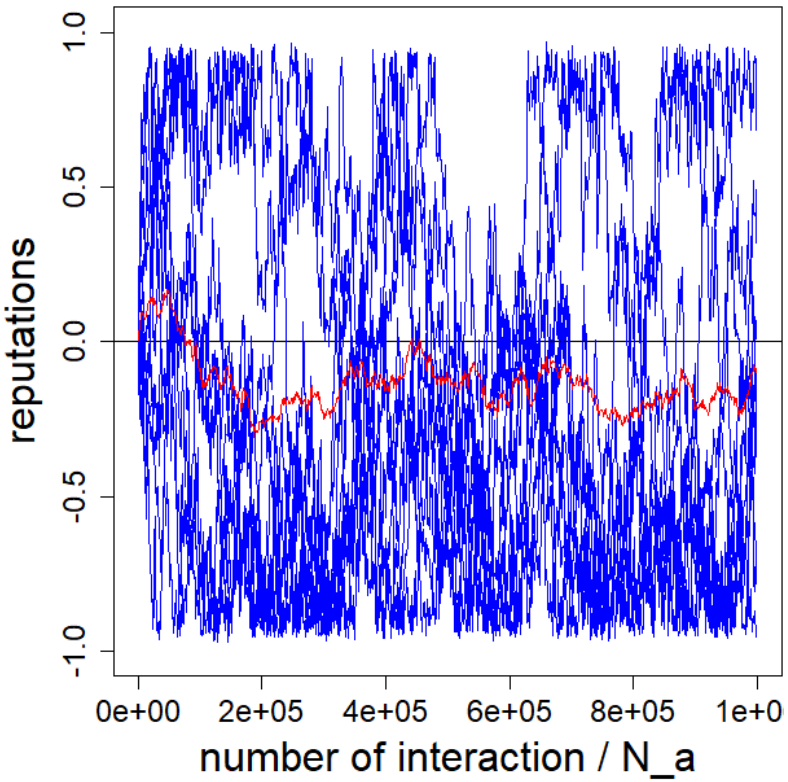


Opinion trajectories

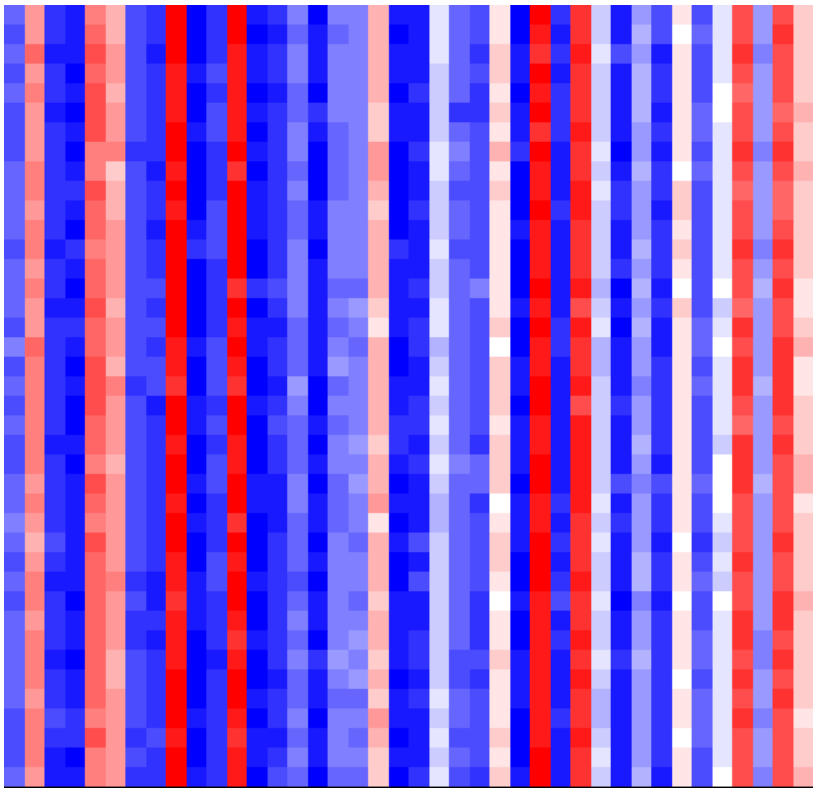


State after 1M pair interactions $\times N_a$

Negative drift with gossip ($k = 5$)



Opinion trajectories



State after 1M pair interactions $\times N_a$

Evolution of average opinions (model of the model)

- Positive bias on the evolution of average self-opinion of i:

$$\overline{x_{ii}}(t+1) = \overline{x_{ii}}(t) + \frac{2}{N_c} \sum_{j \neq i} \left(\widehat{h_{ij}}(t) \left(\overline{x_{ji}}(t) - \overline{x_{ii}}(t) \right) + \overline{h'_{ij}}(t) \left(\overline{x_{ii}(t).x_{ji}(t)} - \overline{x_{ii}^2}(t) \right) \right)$$

- Negative bias on the evolution of average opinion of j about i:

$$\overline{x_{ji}}(t+1) = \overline{x_{ji}}(t) + \frac{2}{N_c} \left(\widehat{h_{ji}}(t) \left(\overline{x_{ii}}(t) - \overline{x_{ji}}(t) \right) + \overline{h'_{ji}}(t) \left(\overline{x_{ji}^2}(t) - \overline{x_{ii}(t).x_{ji}(t)} \right) \right).$$

Deffuant and Roubin, Physica A (2022).

Usual positive bias on self-opinion

- *People overrate themselves. On average, people say that they are "above average" in skill , over-estimate the likelihood that they will engage in desirable behaviors and achieve favorable outcomes, furnish overly optimistic estimates of when they will complete future projects, and reach judgments with too much confidence* (Dunning et al., 2004)

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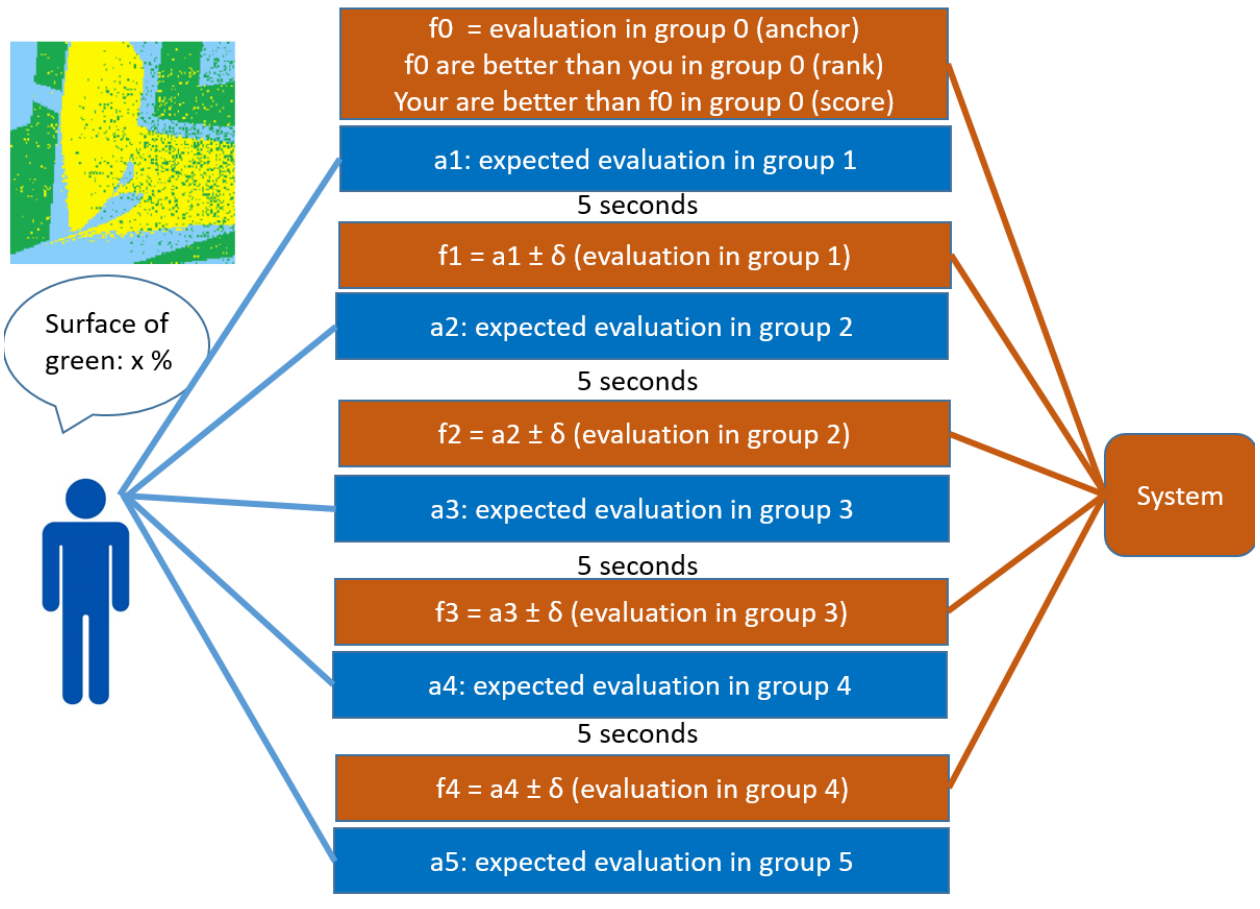
- This bias comes from the tendency to self-enhancement: dismissing negative feedbacks and overrating positive ones. Different from the positive bias emerging in the model.

Experiment

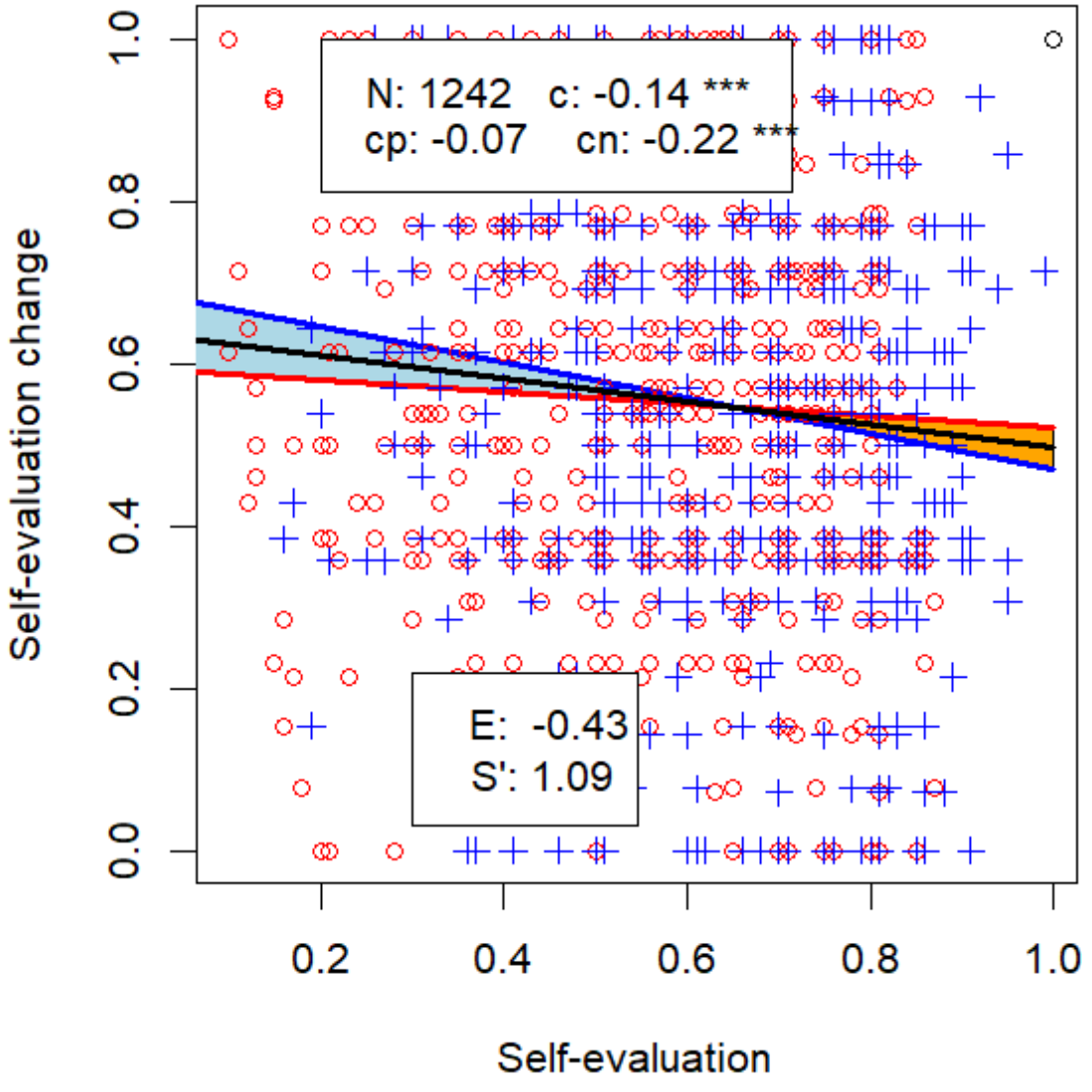
Questionnaire on internet filled by 1500 persons.



Deffuant, Roubin, Nugier and Guimond, Plos-One (2024)

Results

- The sensitivity to feedbacks is decreasing.
- We measure a significant positive bias (around 1 % of δ) for participants believing in feedbacks



Conclusion

- A yet undetected cognitive bias revealed by an agent-based model
- Possible to detect it only with long simulations

Co-authors

Sylvie Huet

Téo Carletti

Thibaut Roubin

Armelle Nugier

Serge Guimond

Discussion

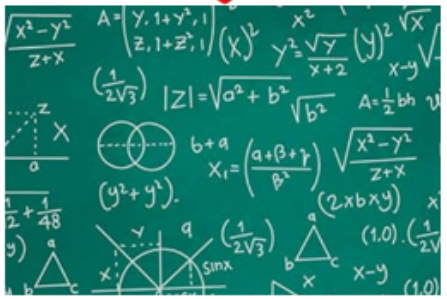
Debate French Presidential election, 1974

Traps of realism

- Can we identify more clearly the traps of realism ?
- Can we identify classes of applications for which we know that there is almost no chance of developing efficient decision support ?

"Toy" agent-based models

- What is the status of these models (Axelrod"s model of cultures, voter model, threshold model, persuasive argument model, etc...)?
- Tentative answer: **General conceptual tools intermediate between mathematics and computer science**.
- Can we classify emergent phenomena (like different phase transitions in physics) ?



Dreamer is still my favourite character in the play

- There are massive social phenomena that we still don't understand (e.g. money, religion, language)
- Maybe we still have to elaborate the right concepts in order to design the appropriate experiments (see the Higgs boson)
- Should models represent or create/change reality ?

Thanks !