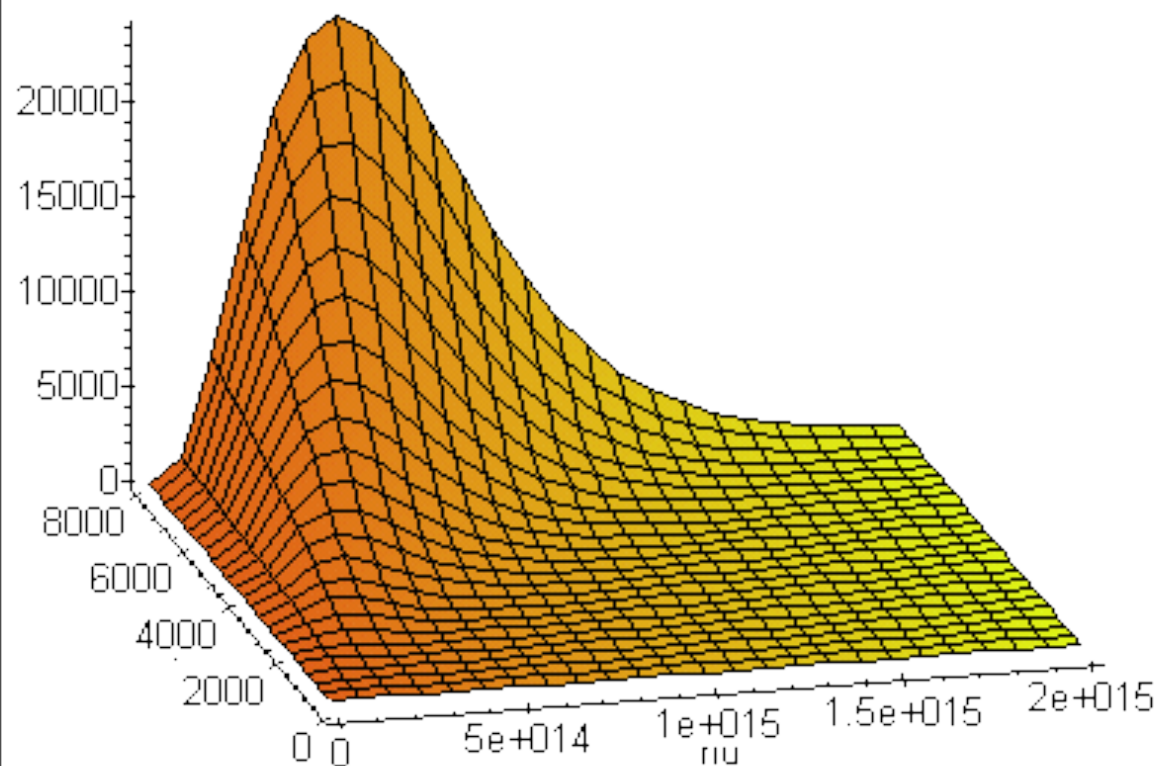
Model building and Validation



Nigel Gilbert

Centre for Research in Social Simulation
University of Surrey

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Overview

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Simulation Innovation: a Node

- Programming tools
- How an agent-based model is constructed
- Verification and validation
- Validation and model objectives
- Where to learn more
  - Further reading
  - Courses

Tools

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AgentSheets

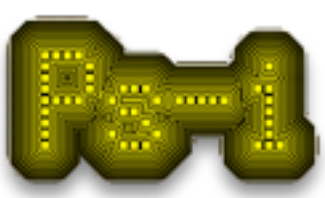
Swarm Development Group
www.swarm.org

Cormas
Natural resources and agent-based simulations
Cirad • Web des SAVOIRS

ASCAPE

M A S O N

RePast



JAS
Java Agent-based Simulation library

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Tools

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- Special purpose ‘toolkits’ and ‘packages’
  - Repast, Mason, NetLogo
  - adaptability? complexity?
- Special purpose simulation language
  - Matlab, Mathematica
  - flexibility?
- General purpose programming language
  - C++, Lisp, Smalltalk, Java
  - development tools?

NetLogo

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- Free
  - but not open source
- Runs on Windows, Mac OS X, Linux
- Own programming language
  - designed for school children
  - distant descendant of Logo
- Good documentation and tutorial
- Very high level language
  - many complicated ideas can be expressed in one or two lines of code
  - built in graphics for plots and controls
- Good user forum
  - provides help if you get stuck

NetLogo

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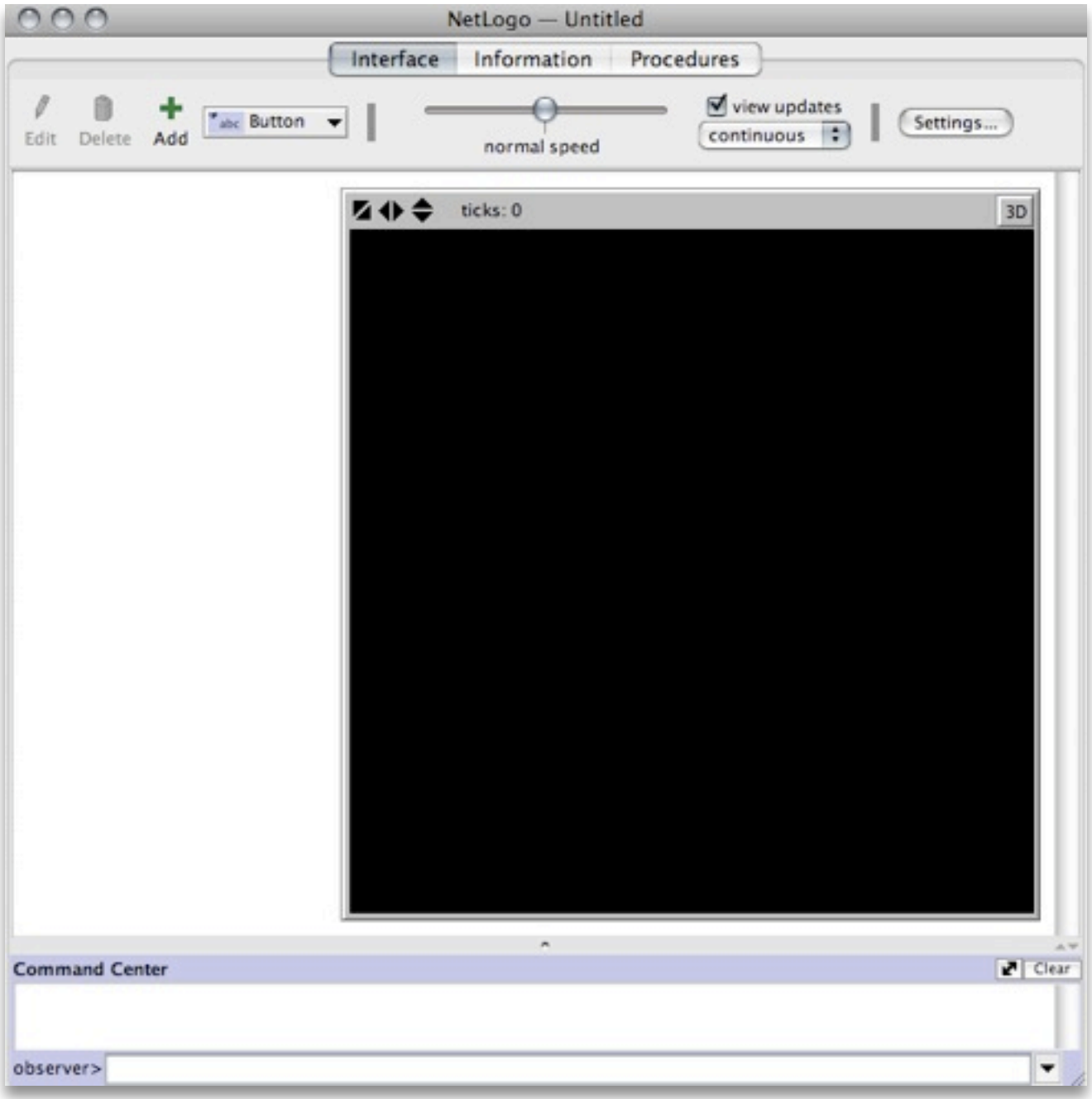

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A very simple NetLogo model

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```
to setup
  clear-all
  create-turtles 10
end

to go
  ask turtles [
    right (random 360)
    forward 1
    ]
end
```


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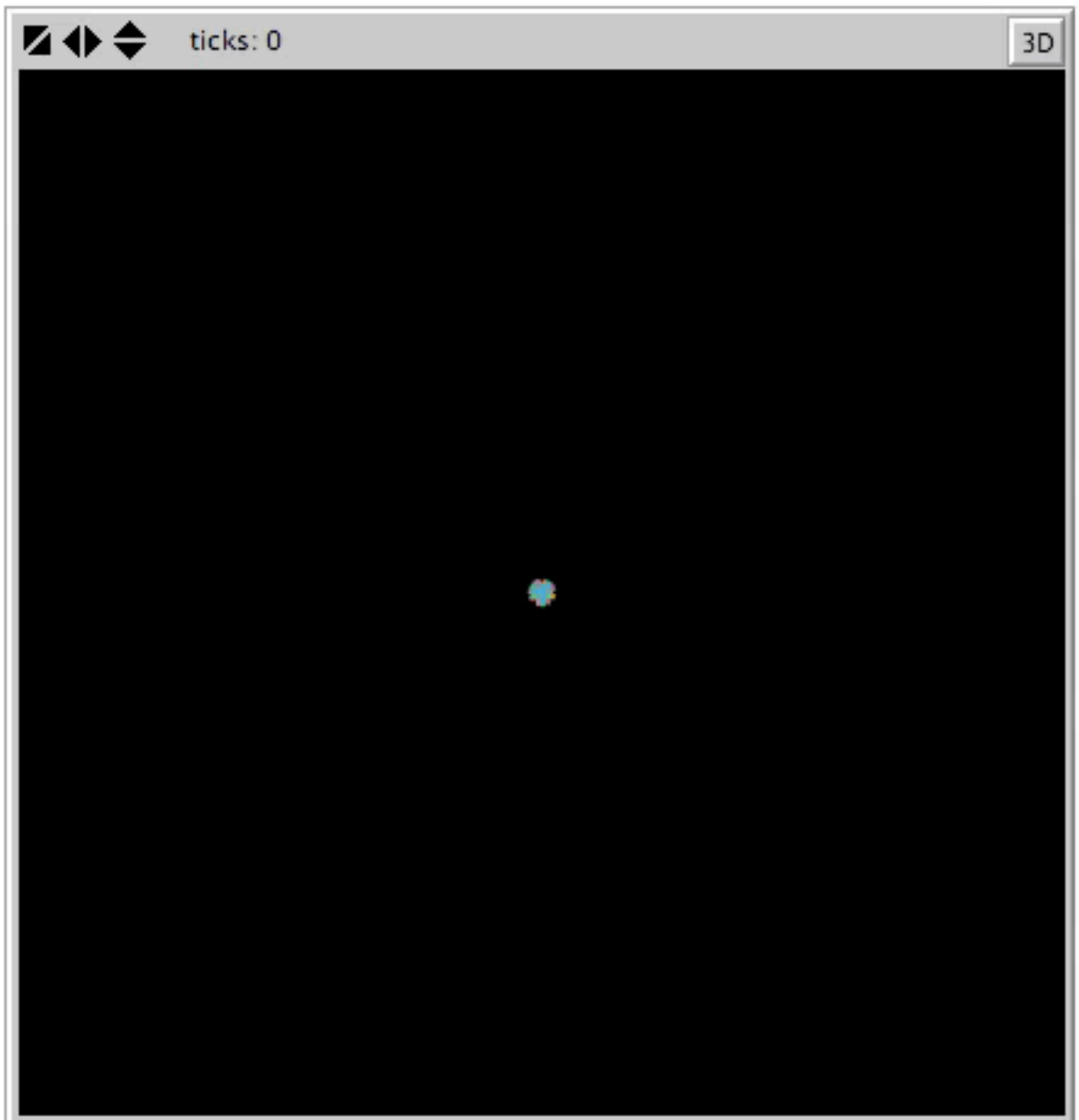

Setup

Go

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A very simple NetLogo model

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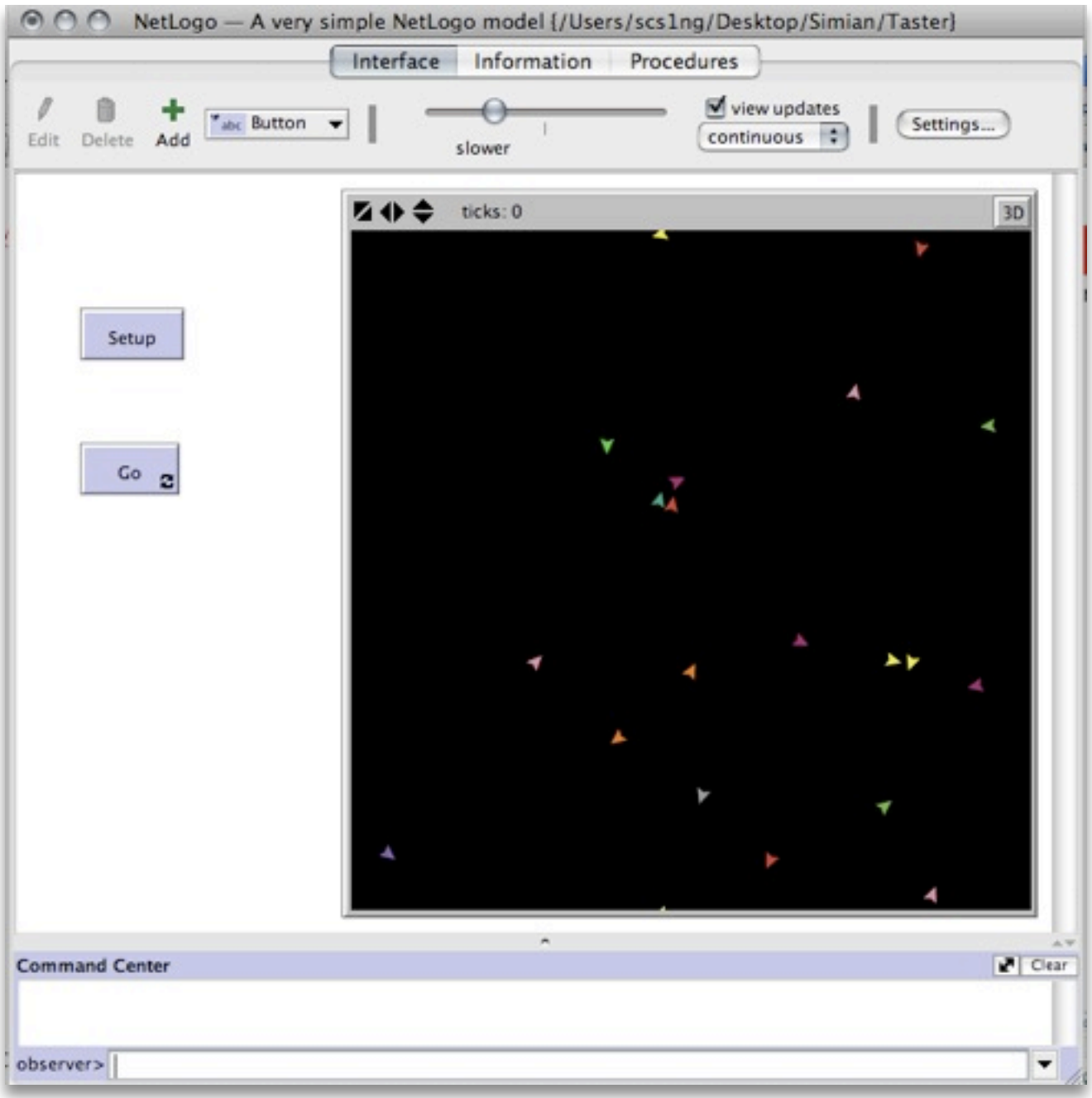

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Verification and validation

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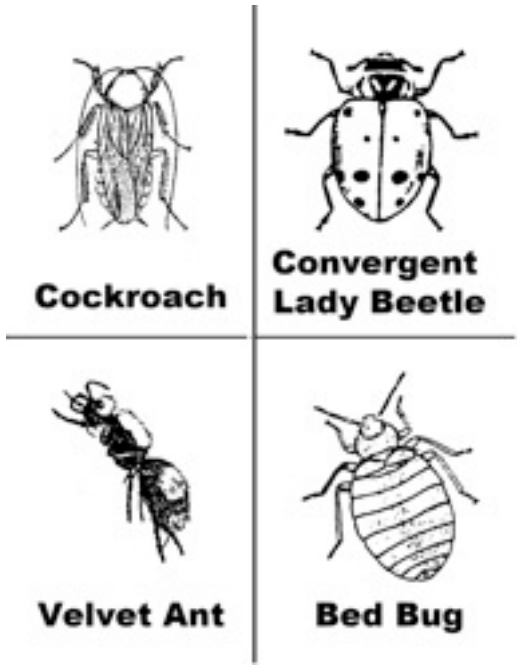

- Verification
  - **Is the model right?**
  - Getting rid of bugs
- Validation
  - **Is it the right model?**
  - Checking whether the model is a *good* model of something
  - 'Good' depends on one's objectives

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Validation

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- Is the model a good model?
- It depends on the modeller's objectives
  - Formalising a theory
    - Usually an abstract model
  - Developing middle range theory
    - Model of a class of phenomena
  - Modelling a specific situation
    - Facsimile models

Abstract models

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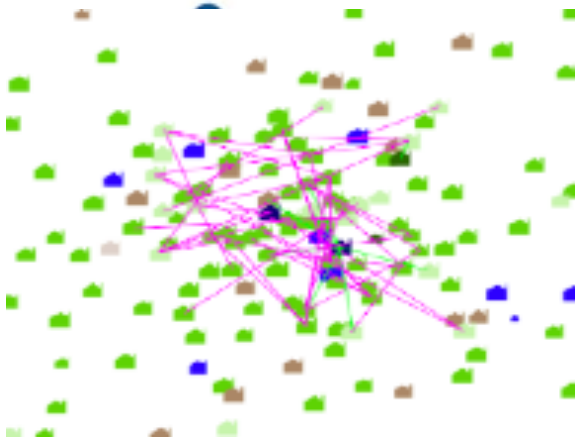
- Aim: demonstrate some (probably emergent) social process or mechanism
- No corresponding specific empirical case
- Example:

  Models of opinion dynamics

- Validation criterion:

  Does it generate more specific ('middle range') theories that can be tested empirically?

Middle range models



- Aim: describe the general characteristics of a particular social phenomenon
- Should be applicable to many specific cases
- Example:

  models of innovation networks, supply chains
- Validation criterion:

  Qualitative resemblance

  Similar dynamics

  'History friendly' models

Facsimile models

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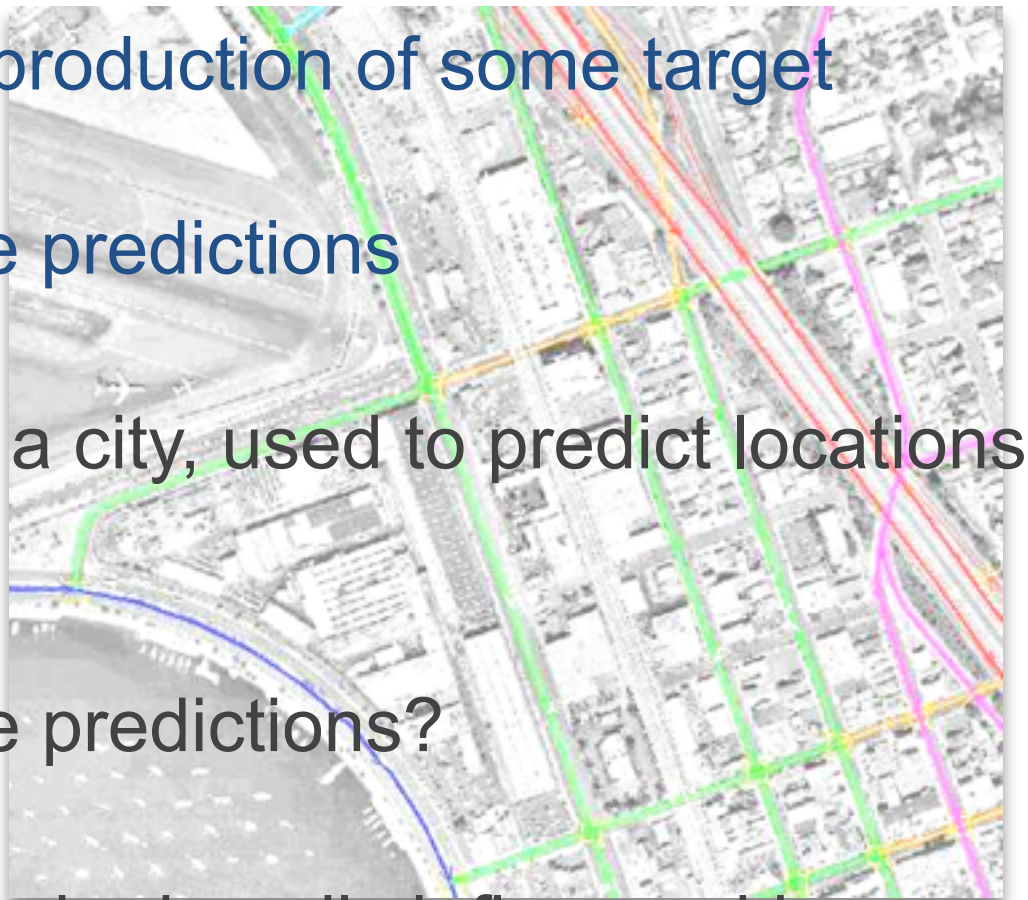
- Aim: provide an exact reproduction of some target phenomenon
- Often intended to provide predictions
- Example:

  a model of the traffic in a city, used to predict locations of potential jams
- Validation criterion

  Does it lead to accurate predictions?
- Problem:

  behaviour of model may be heavily influenced by random events (simulated using a random number generator)



Comparing outputs with observed data

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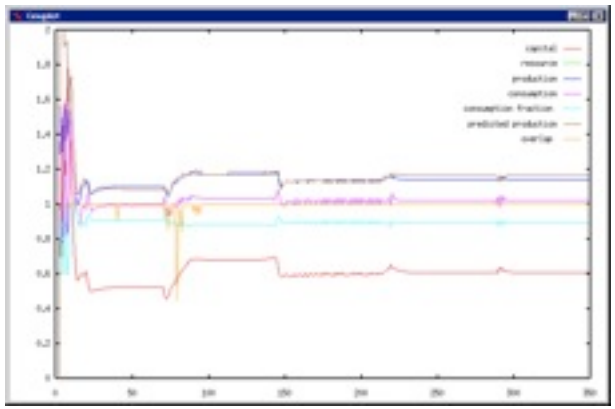
- ‘Observations’ may be impossible
  - too abstract
  - inaccessible (e.g. social complexity in 20,000BC)
- Differences may be due to any or all of:
  - bad model
  - bad data
  - model is an abstraction of the target
  - ‘random’ variations, but sampling distributions are unknown

Comparing model output and data



- Basic idea:
  - Use the same statistics as one would use to compare a statistical model with data
    - E.g. R^2, the regression coefficient
    - Spearman's rho for ordinal data
    - Measure of association such as phi for categorical data
  - Caution!
    - It is unlikely that the model output will be normally distributed
    - When comparing time series, consider auto-correlation
      - i.e. value at time *t*+1 is not independent of value at time *t*

Validity

- Other related questions
  - sensitivity to values of the input parameters
    - do small changes in the values of the inputs result in large changes in the outputs?
    - if so, are you sure that the values used are the right ones?
  - repeatability
    - is the output similar on every run?
    - if not, are you sure that the runs are typical?
  - simplicity
    - could the model be simplified without affecting its validity?
    - if so, why use a more complicated model than necessary?

Validity

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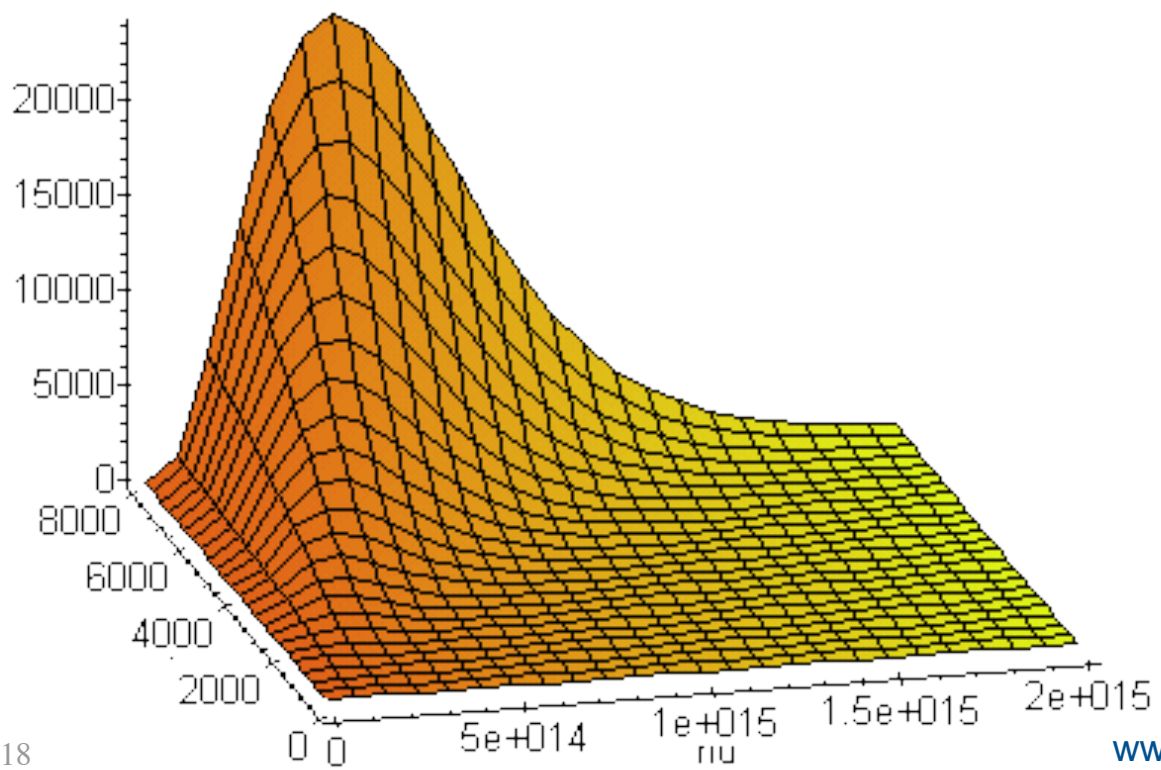
- Sensitivity analysis
  - repeatedly run the model with small variations in input parameters and observe outputs
  - but the space of possible input values is exceedingly large



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Questions?

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.... and then some suggestions for further reading

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To learn more

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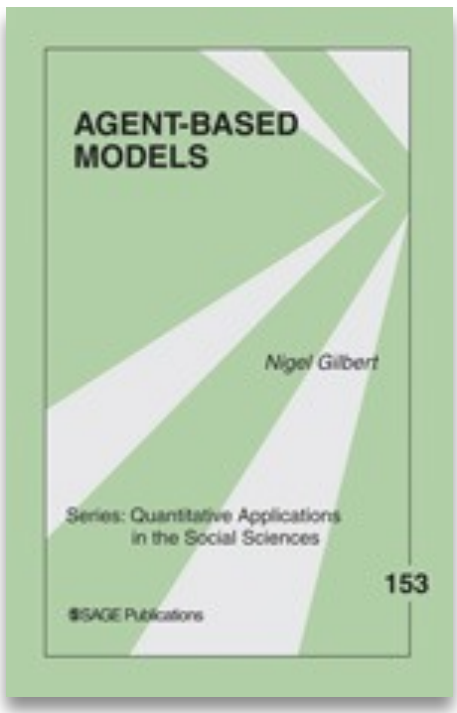
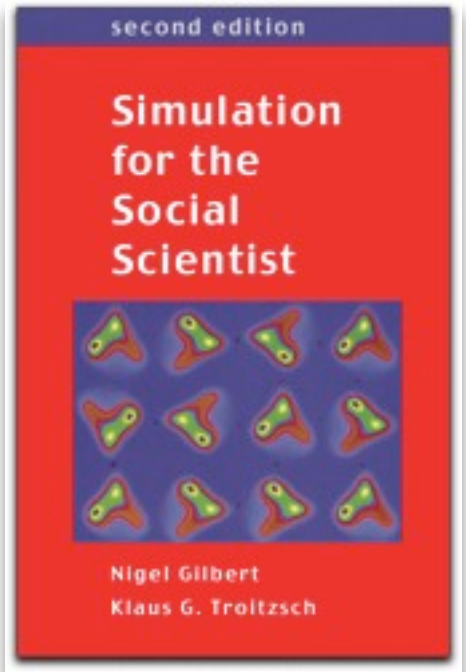
http://www.soc.surrey.ac.uk/JASSS/

JASSS

Journal of Artificial Societies and Social Simulation





essa

European Social Simulation Association
http://www.essa.eu.org

www.simian.ac.uk

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Email list

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- http://www.jiscmail.ac.uk

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