Spatial modeling

a brief overview

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What's a model?

- "useful representation" (Starfield 1997)

- whenever you represent a system in any way and learn something from it
  you got yourself a model

What can models do?

- help us understand a system

- describe a system

- predict long term dynamics from snap-shot data

⟶ predict systems reaction to interference

→ develop resource-efficient control measures

Ok, so modeling is good, sawa. But why spatial modeling? It's soo complicated!

What's epidemiology?

spatial

- distribution of diseases in populations as well as factors influencing their occurrence

Thrusfield, M. (1995): Veterinary Epidemiology. Blackwell Science

- epidemiology is the ecology of diseases

„Unter Oecologie verstehen wir die gesamte Wissenschaft von den Beziehungen des Organismus zur umgebenden Außenwelt."

Ernst Haeckel 1866

"ecology is the science of the relationships of the organism to the surrounding world"

space

Some more points about space in epidemiology

- "**spread**" of disease

- host populations are distributed in **space**

- direct transmission:
  - 2 animals must be in the same point in **space** at the same time

- indirect transmission (e.g. via parasite eggs):
  - 2 animals must be in the same point in **space** at different times

- indirect transmission (e.g. vectors):
  - an infected host and a vector must be in the same point in **space**, same time
  - a susceptible host and a vector must be in the same point in **space**, same time

Disease dynamic is a **spatial** process!

and therefore should be modeled spatially

What kind of models are we talking about?

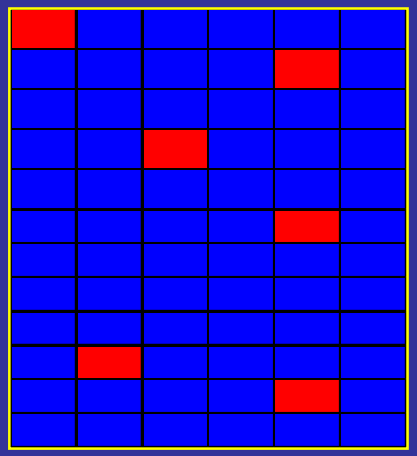
Agent-based, spatially-explicit dynamic system model

- Agents = things; entities that are individually represented in a model
- Agents have individual characteristics (age, infection history, position, …)
- Spatially-explicit: things have a position in space
- The spatial position of agents influences what happens to them
- Dynamic system model:
- Set of agents and a set of processes that change state of agents
- Processes are applied periodically (time discrete), state of agents updated

Highly flexible, widely used in ecology, no restrictions by math

How do spatial models look like?

grid-based models, generalization of cellular automata



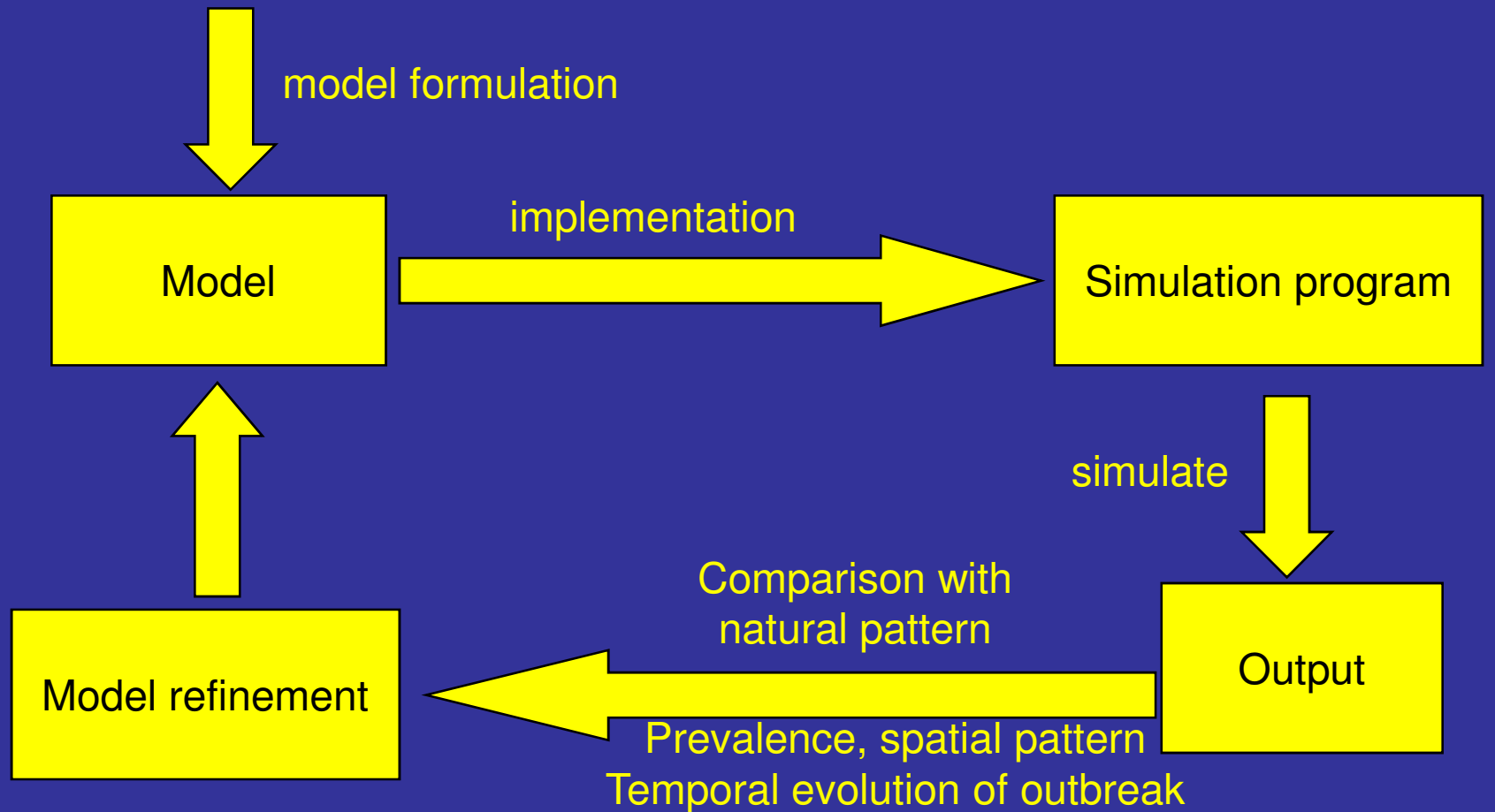
- landscape divided into uniform squares (grid cells)
- size of grid cell determined by ecological factors
- homogeneity within grid cells
- grid cells can be farms, areas…
- can have different characteristics (risk factor map)

animals (as agents)
- live within grid cells
- travel between grid cells
- risk pathways modeled between grid cells

How are these models analyzed?

Pattern-oriented modeling

Lite Grimm, V, et al. (2005) *Science* 310, 987-991. ience



What do we need to make such a model for HPAI in Nigeria?

- spatial data on risk factors (Rapha)

- spatial data on poultry population, i.e. poultry production industry

- **complete, quantitative Risk Pathway Analysis**

A Demonstration for Nigeria

- no risk maps, just homogeneous landscape

- no risk pathways, just simple spatial spread kernel

- culling:
  - detection at 10% prevalence
  - 5 grid cells culling radius

→ all very crude

Not a simulation model, just a demonstration!