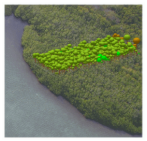
TECHNISCHE UNIVERSITÄT DRESDEN

Faculty for Forest, Geo- and Hydrosciences - Department of Forest Sciences
Institute for Forest Growth and Computer Sciences – Professorship of Biometry and Systems Analysis

Introduction Into Agent-Based Modelling

Uta Berger

Motivation

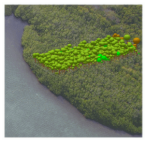


- Agent-Based Modelling (ABM) relatively new approach
- Aim: understand the dynamics of complex socio-economic systems
- Tools: simulation models & computer experiments

- Examples: manifold
  - agent behaviour in the stock market (Arthur et al. 1997)
  - predict the spread of epidemics (Bagni et al., 2002)
  - supply chains (Macal 2004)
  - understand the fall of ancient civilizations (Kohler et al, 2005)
  - analyse the purchase behaviour of people (North et al, 2009)
  - many others

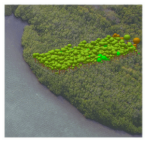
ERGO: ABM seems to be suitable to predict the adaptation strategies of Andean people to climate change and their effects on livelihood (INCA project).

Content



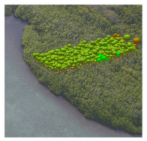
- Motivation
- Basic principles of Agent-Based Models
- 1st Example: Segregation Model
- 2nd Example: Risk Management in Semi-Arid Rangelands
- Conclusion

Basic principles of Agent-Based Models



A typical ABM has three elements:

1. A set of agents
2. A set of agent relationships
3. The agents' environment



Interaction with other agents

Agent

Attributes:

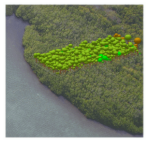
Static: name, gender, ..

Dynamic State Variables: age, resources, neighbours, ..

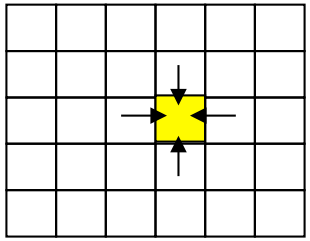
Behaviour:

farming, responses to neighbours' activities, update rules to change dynamic state variables, ..

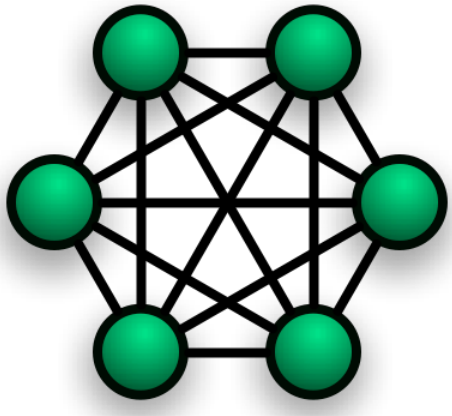
Environment



The topology of interactions can be manifold:

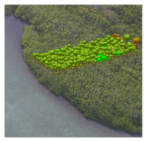


Cellular Automaton



Network

GIS System



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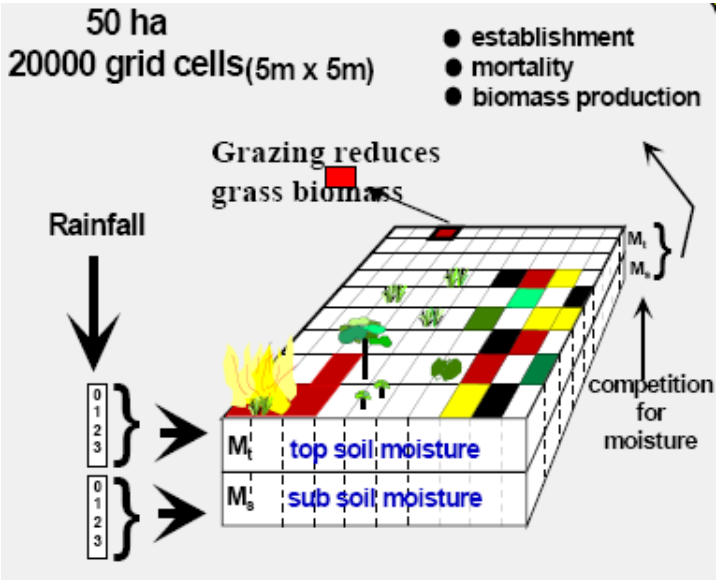


Florian Jeltsch u.a. Uni Potsdam (1996, 97, 98, 99, 2000)

.. also interactions with the biotic and abiotic environment.

1st Example: Segregation Model

Thomas Schelling
(American Economist
Nobel Prize in Economic sciences 2005)

Modeling civil violence: An agent-based computational approach

Joshua M. Epstein[†]

Center on Social and Economic Dynamics, The Brookings Institution, 1775 Massachusetts Avenue, NW, Washington, DC 20036; and External Faculty, Santa Fe Institute, 1399 Hyde Park Road, Santa Fe, NM 87501

This article presents an agent-based computational model of civil violence. Two variants of the civil violence model are presented. In the first a central authority seeks to suppress decentralized rebellion. In the second a central authority seeks to suppress communal violence between two warring ethnic groups.

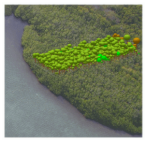
assumed to be based on these variables. Of the many functional relationships one might posit, we will assume:

$$G = H(1 - L).$$

Grievance is the product of perceived hardship (**H**) and per-

PNAS | May 14, 2002 | vol. 99 | suppl. 3 | 7243-7250

1st Example: Segregation Model



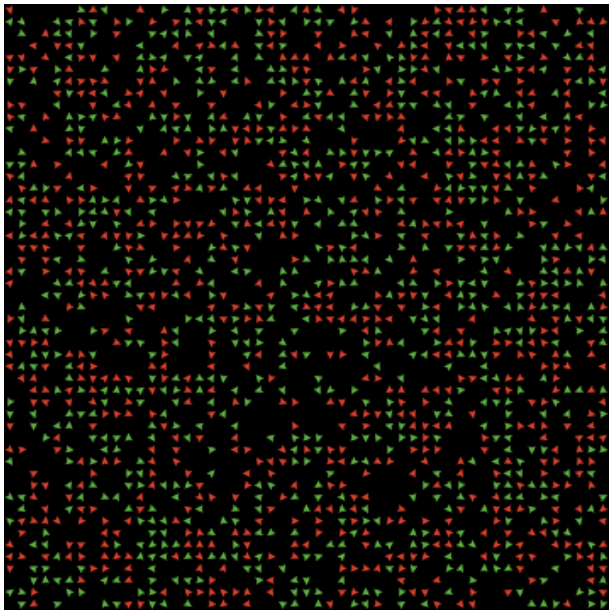
Research question

How does the segregation (people of the same culture, income, colour .. are more likely to live I the same neighbourhood) we observe in our cities appear?

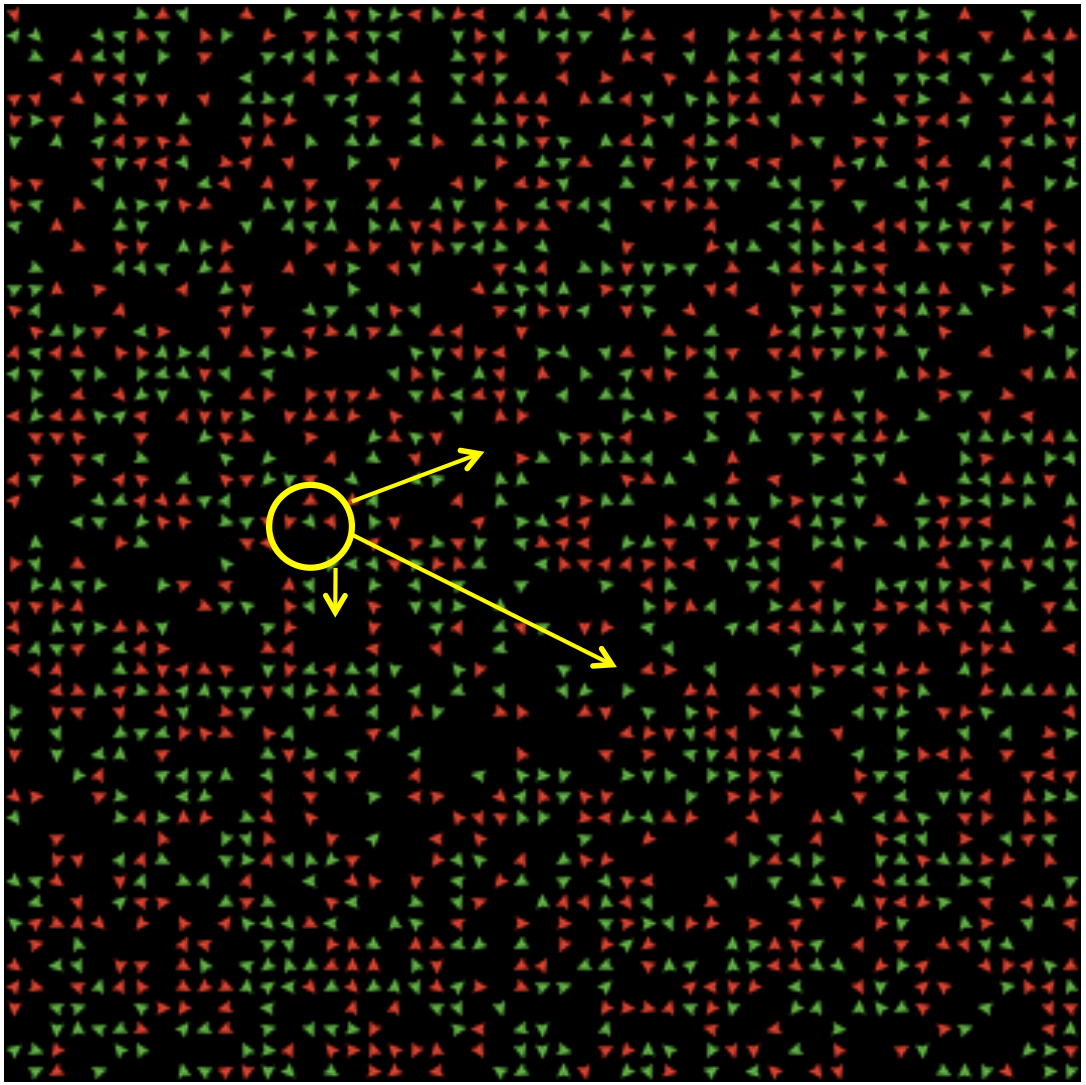
Rule

IF (more than 2 of your 8 neighbours do not have the same colour)

THEN (move to a new location)

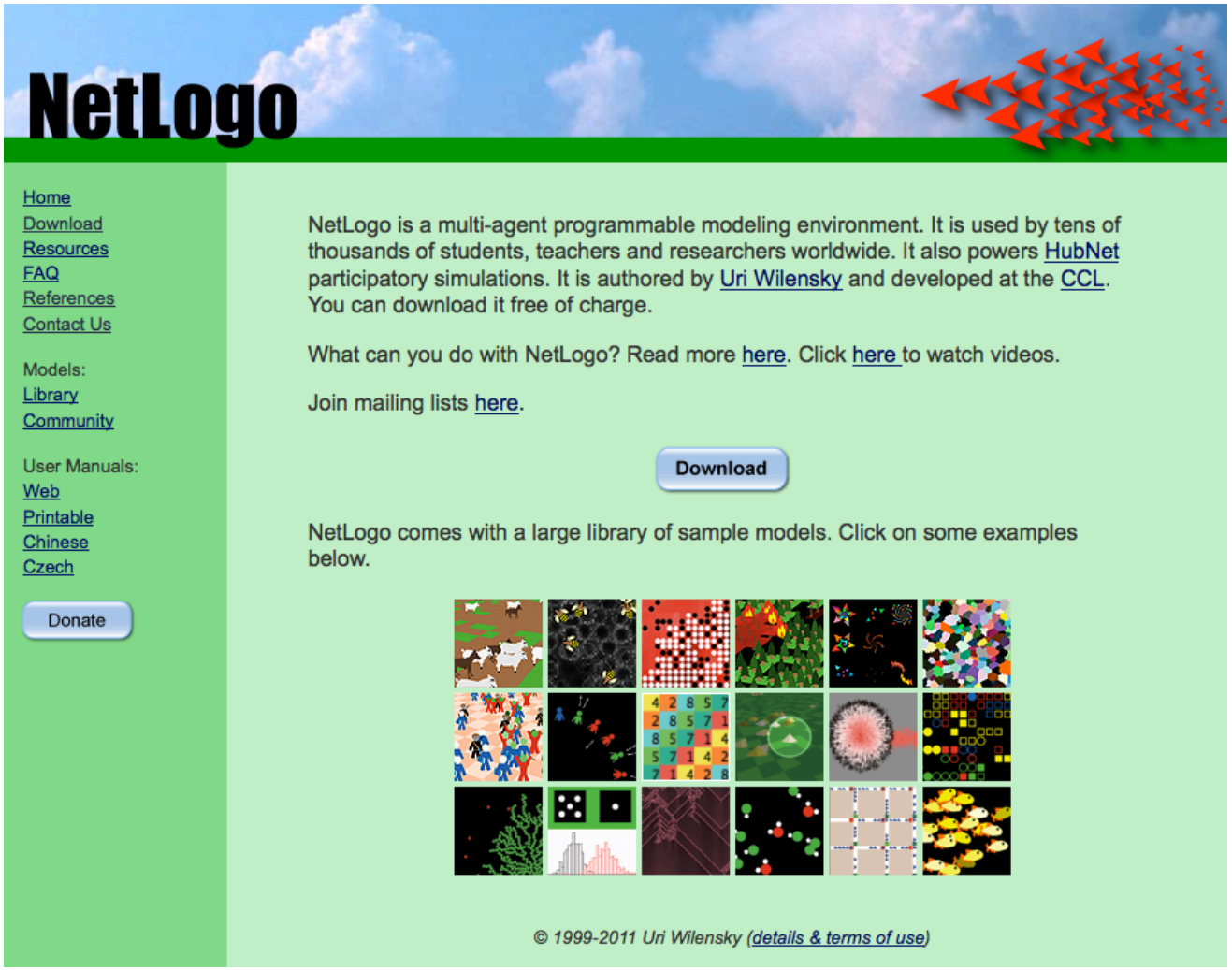


1st Example: Segregation Model



Move to an empty spot.

NetLogo is a platform for developing and testing ABMs and the best way to start with:



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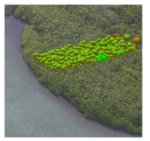
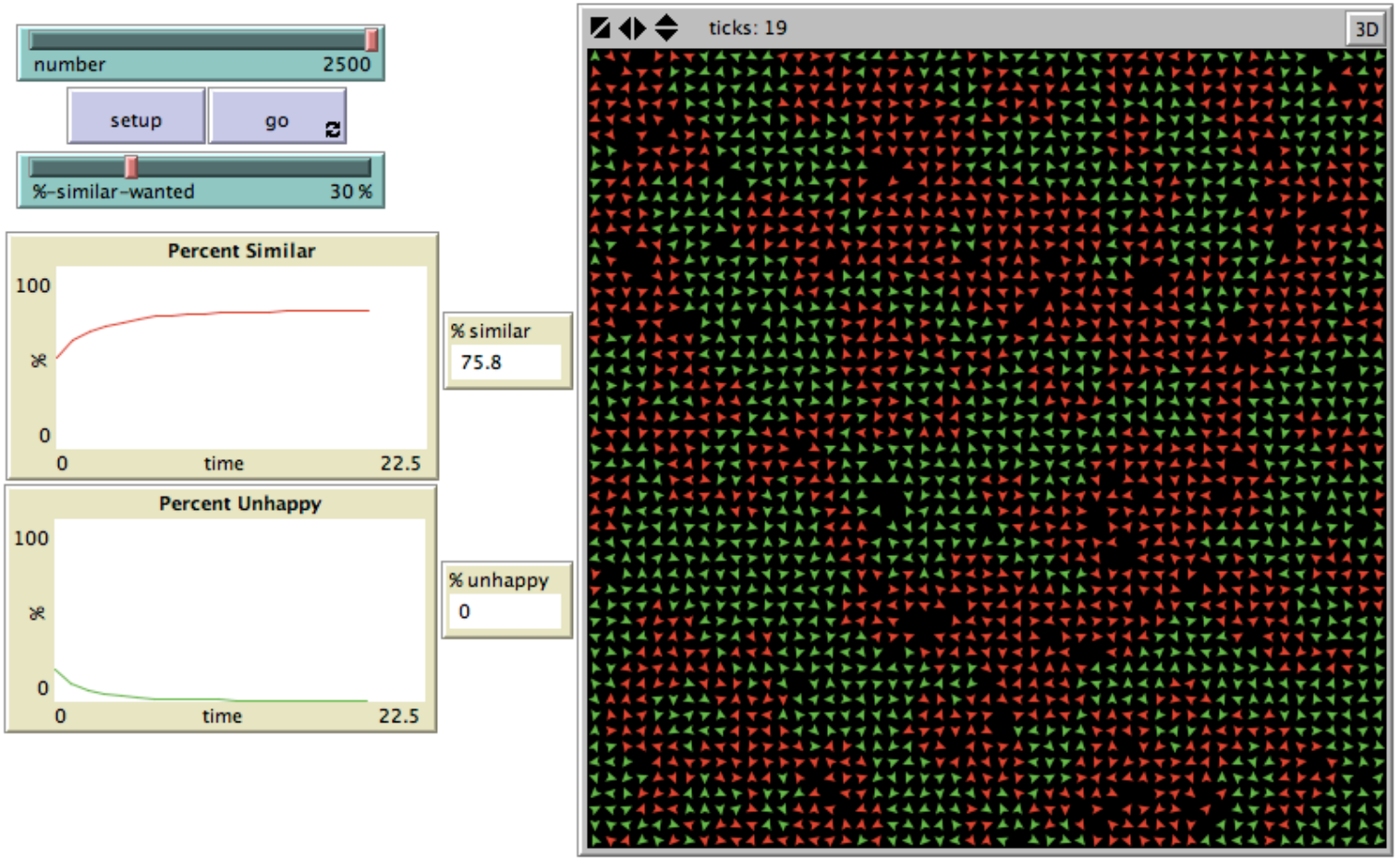
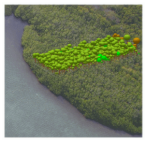


Interesting: even if all people seem to be tolerant (want only 30% similarity) you and up with an average of > 70% similarity (and segregation)



1st Example: Segregation Model



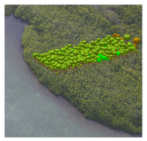
Advantage of the model:

- we learned about the emergence of a common social pattern
- we understood that the system shows a “threshold” behaviour
  (similarity demanded < 30% no segregation,
  similarity demanded > 30 % segregation)
- this model stimulated a bundle of subsequent studies

BUT no proof that we can use the ABM approach for the INCA project

Adaptation to spatio-temporal variability in semi-arid rangelands
Oliver Jacoby (2011)

2nd Example: Rangeland model



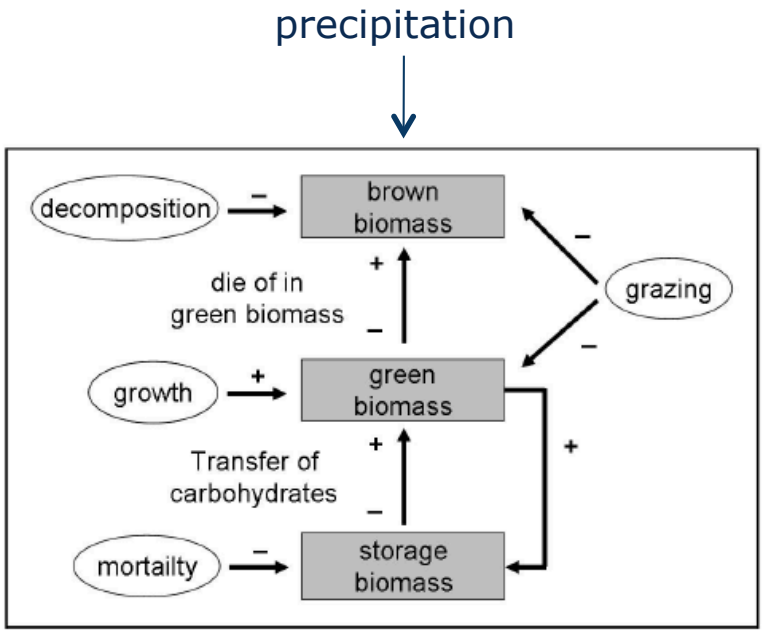
Purpose

Improve the understanding of different rangeland management approaches.

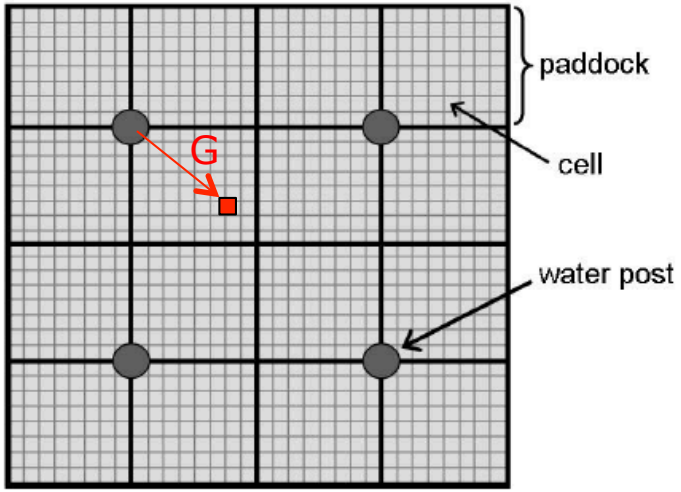
Research questions

1. How can farming system adapt to the spatial and temporal heterogeneous resource availability in semi-arid areas?
2. How effective are these strategies under stochastic environmental conditions in comparison to constant conditions?

2nd Example: Rangeland model



strength of grazing depends on distance from water post

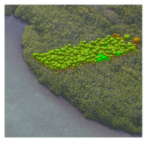


Conceptual structure of the model (Jacoby et al. 2010)

For example: $G = \exp(-D) \cdot P$

G .. grazing activity
D .. distance from water post
P .. preference for food

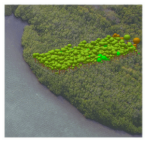
2nd Example: Rangeland model



Management strategies tested:

	Strategy	**Description**
NAR	Non-adaptive rotation	fixed paddock sequence for livestock rotation
AR1	Adaptive rotation 1	always graze paddock with highest above-ground biomass (AGB)
AR2	Adaptive rotation 2	rainy season: graze always paddock with highest AGB dry season: graze always paddock with lowest AGB
NAST	Non-adaptive stocking	constant stocking – fixed amount of livestock
AST	Adaptive stocking	opportunistic stocking – depends on amount of AGB

2nd Example: Rangeland model

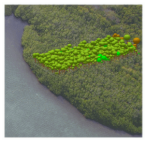


Climate scenarios evaluated:

monthly precipitation: $r = \log Norm(\bar{r}, \sigma_r)$

Scenario	**mean rainfall** $\bar{r}$	**variance of rainfall** σ_r	**length of rainfall**	**Description**
constant	1	0	18 weeks	const. rainfall with a fixed length of rainy season
stochastic	1	0.25	15-21 weeks	stochastic rainfall with a variable length of rainy season

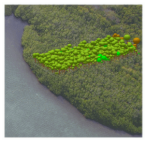
2nd Example: Rangeland model



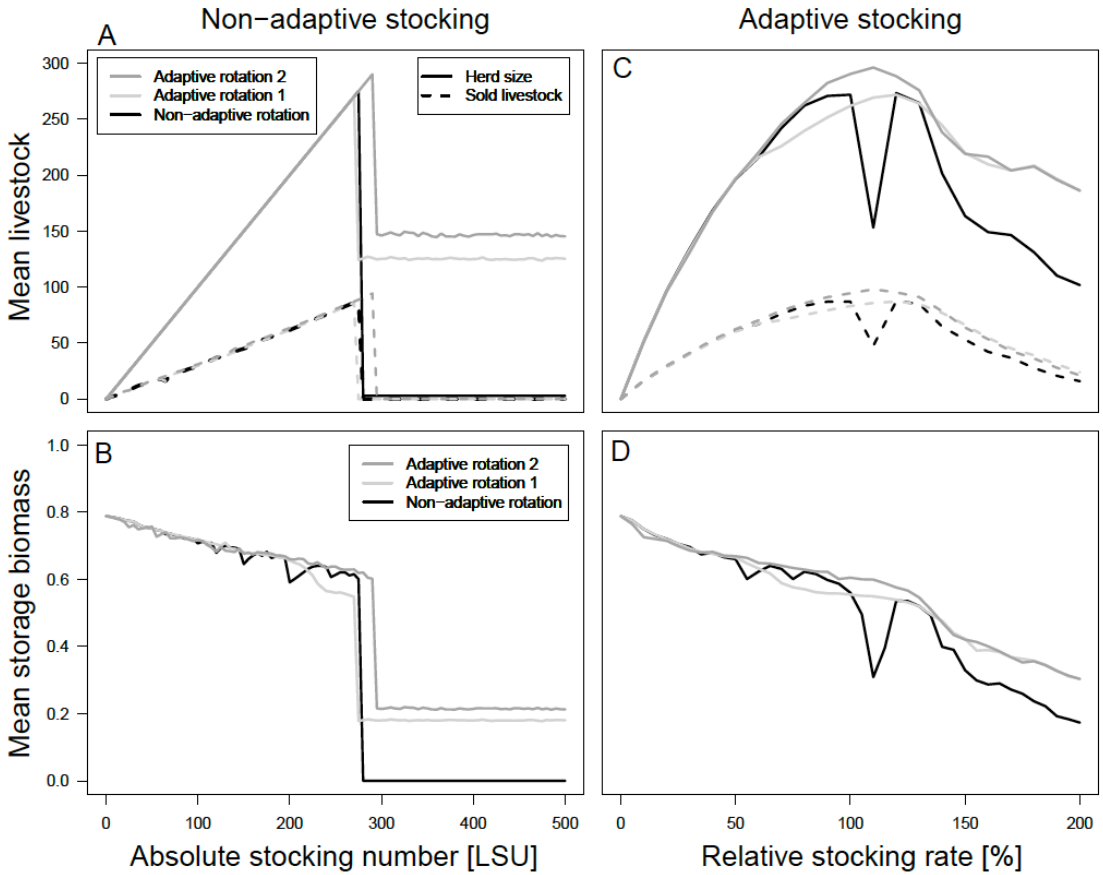
Evaluation of the suitability of the management strategies

Indicator of sustainability	**Description**
ecology	amount of storage biomass (vigour) of the farm
economy I	livestock sold at market
economy II	herd size at farm

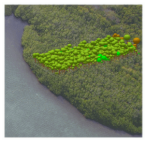
2nd Example: Rangeland model



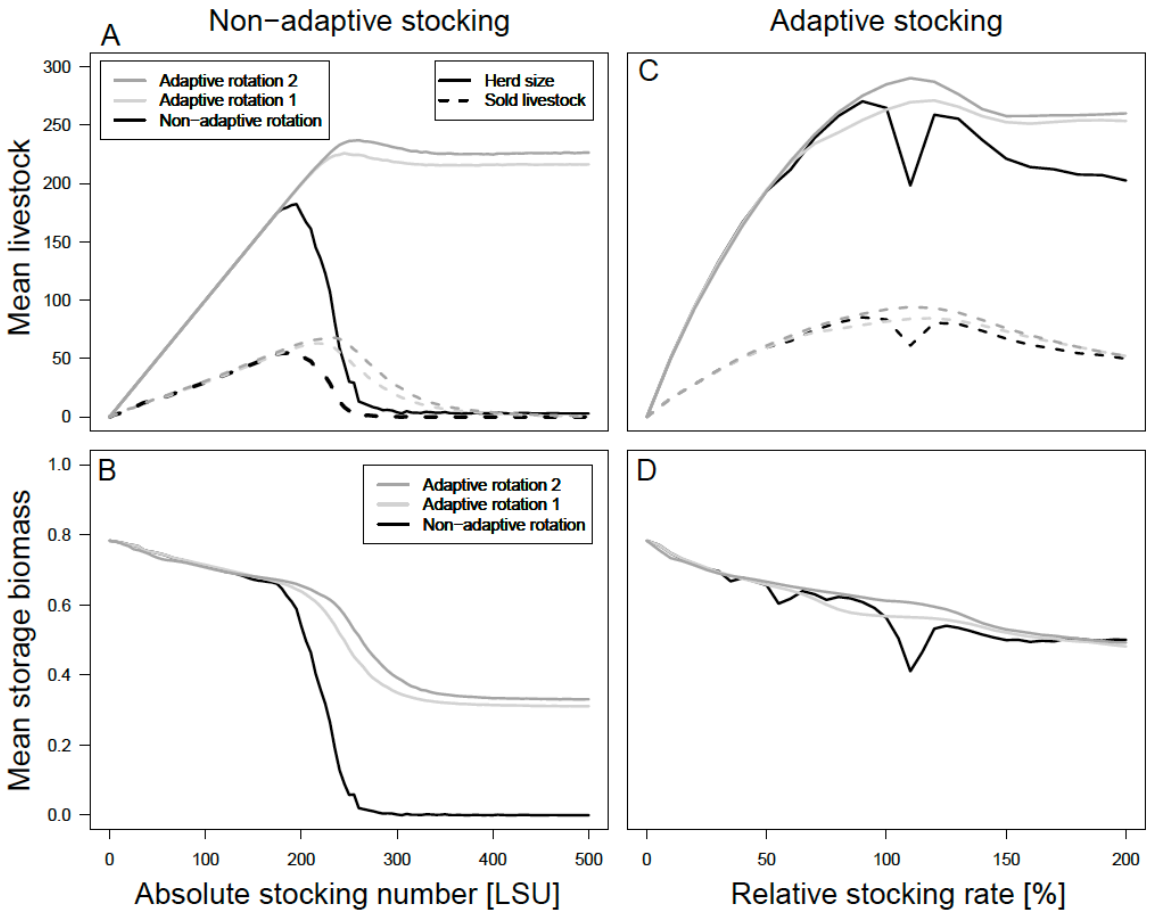
Results – for constant climate



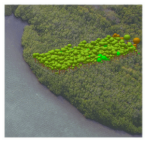
2nd Example: Rangeland model



Results – for stochatic climate



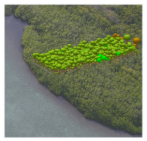
1st Conclusions – for the Rangeland model



What did we learn?

- Stochasticity changes systems behaviour
- Adaptation trades off non-adaptation strategies
- The most suitable strategy depends on the overall settings

General Conclusions

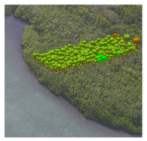


ABM is good for you!

ABMs are useful tools to predict the potential outcome of adaptations to climate change.

ABMs base on system knowledge and information obtained by social scientists, ecologists, economists …

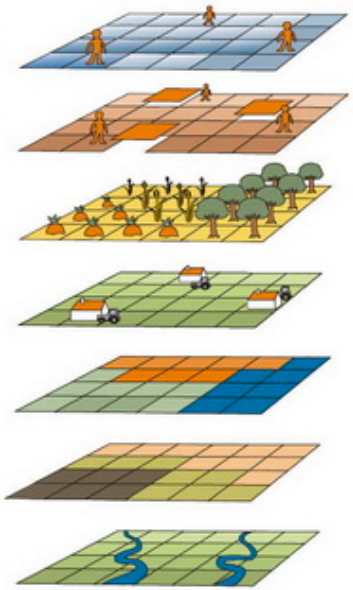
You want more?



Don’t miss the following presentation:

Understanding the effects of climate change on the livelihood strategies of small farmers of the Andean region

Vidal, M., Tuesday 2nd August 2011



Layers

Communication networks

Land and water transactions

Land use

Farm holdings

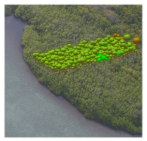
Ownerships

Soil properties

Water flow

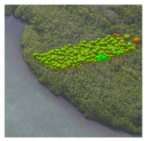
MP-MAS
developed by the team of T. Berger (Uni Hohenheim)

You want learn it?



Join our summer school: 6th TU Dresden Introductory Course in Individual- and Agent-Based Modelling

7.- 15. June 2012



Thank you…

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