

ETH  
INTERNATIONAL CONFLICT RESEARCH  
Exploring Geopolitics with Agent-Based Modeling

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*Prepared for presentation at the workshop "Multi-Agent Simulation as a Social Science Methodology," University of Tokyo, September 24-25, 2005*

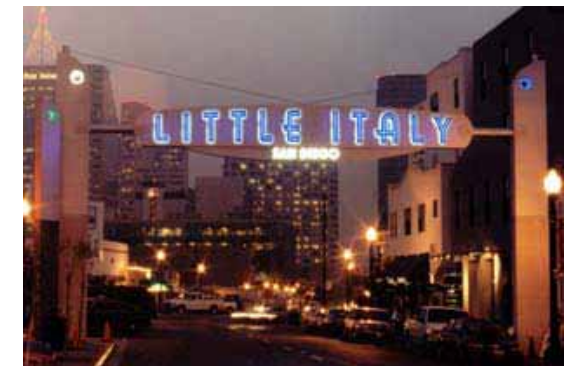
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Outline

1. Theoretical background
2. Introduction to Geosim
3. Four applications to geopolitics
  - War-size distributions
  - State-size distributions
  - Democratic peace
  - Emergence of the territorial state
4. Future research

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A view from the Berlin television tower



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Ethnic neighborhoods



*Little Italy, San Diego*

*Chinatown, New York City*

# Neighborhood segregation

Micro-level rules of the game



Stay if at least a third of neighbors are "kin"



$< 1/3$   
 Move to random location otherwise



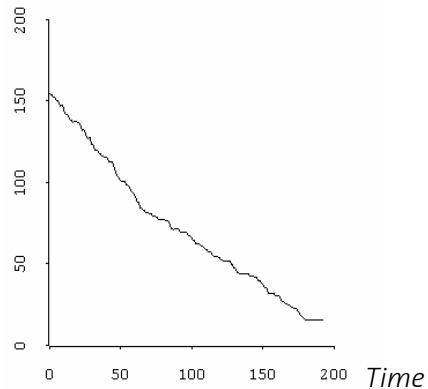
Thomas C. Schelling  
*Micromotives and  
 Macrobehavior*

# Sample run 1

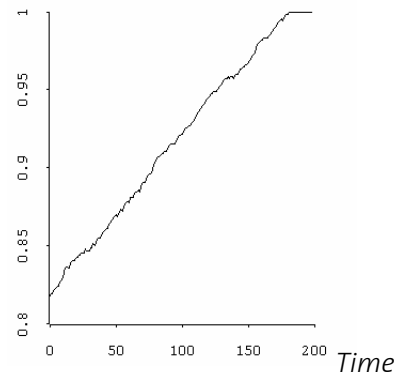
- [Schelling's Segregation Model](#)

# Emergent results from Schelling's segregation model

Number of neighborhoods



Happiness



# Europe in 1500



## Europe in 1900

9



“States made war and war made the state” *Charles Tilly*

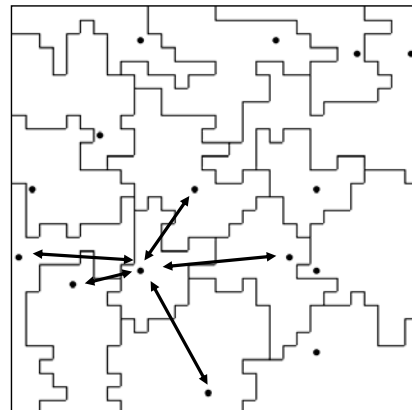
10



## Geosim

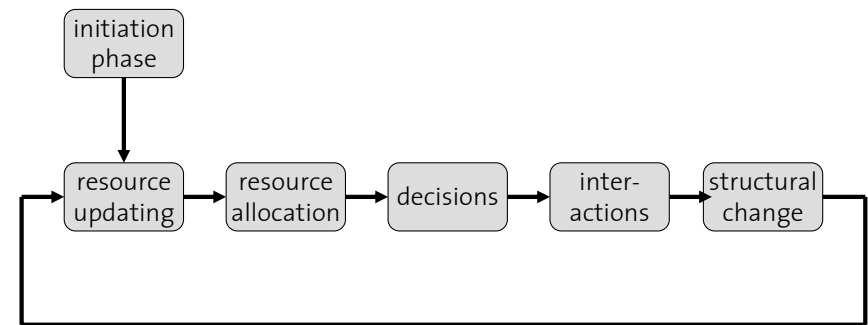
11

- Geosim uses Repast, a Java toolkit
- States are hierarchical, bounded actors interacting in a dynamic network imposed on a grid



## Main simulation loop

12

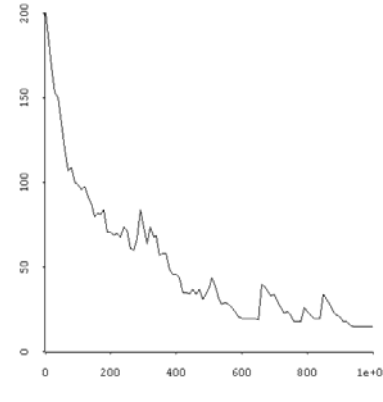


# Sample Run 2

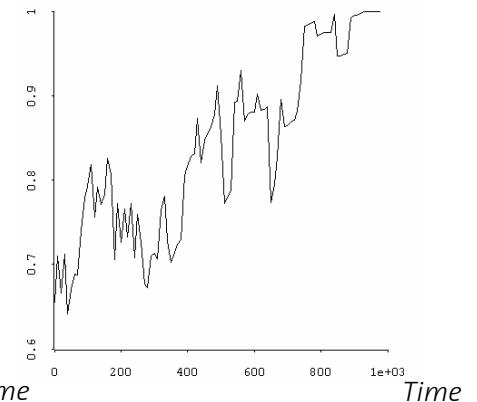
- Geosim Base Model

# Emergent results from the run

Number of states

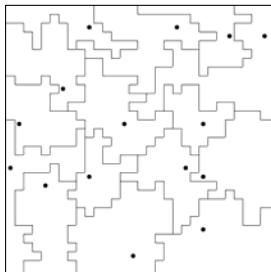


Proportion of secure areas

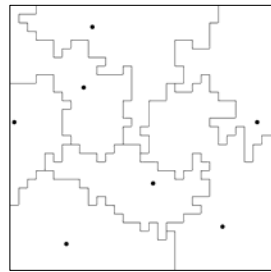


# Possible outcomes

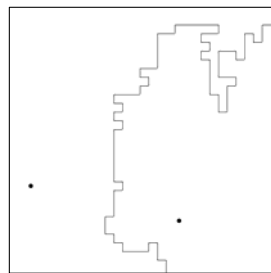
15-state multipolarity (sample run)



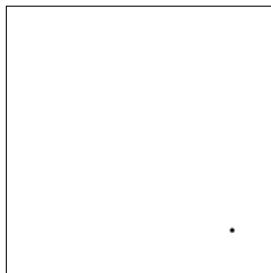
7-state multipolarity



bipolarity



unipolarity



# Applying Geosim to world politics

Configurations

Processes

Qualitative properties

Example 3.  
Democratic peace

Example 4.  
Emergence of the territorial state

Distributional properties

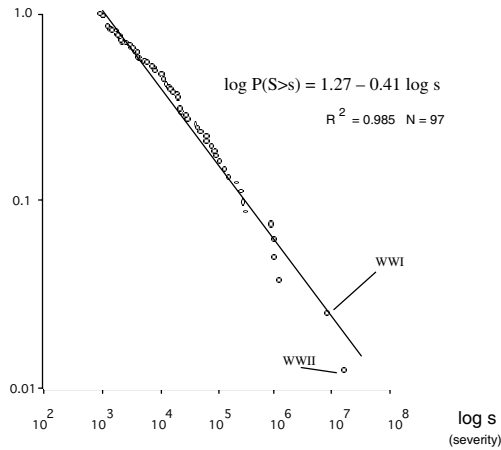
Example 2.  
State-size distributions

Example 1.  
War-size distributions

# Cumulative war-size plot, 1820-1997

17

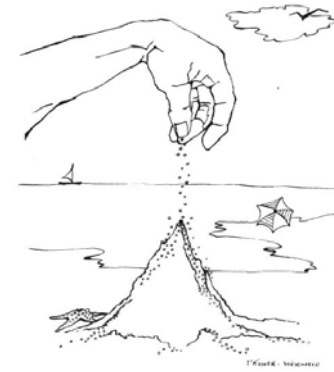
log P(S>s)  
 (cumulative frequency)



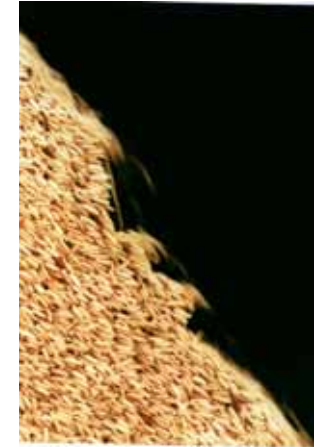
Data Source:  
 Correlates  
 of War  
 Project (COW)

# Self-organized criticality

18



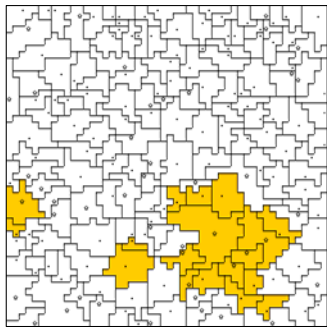
Per Bak's sand pile



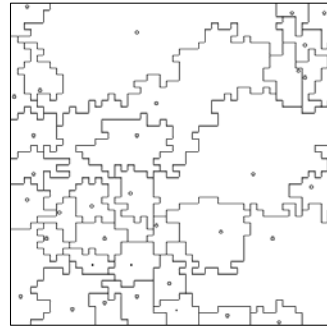
Power-law distributed  
 avalanches in a rice pile

# War clusters in Geosim

19



t = 3,326

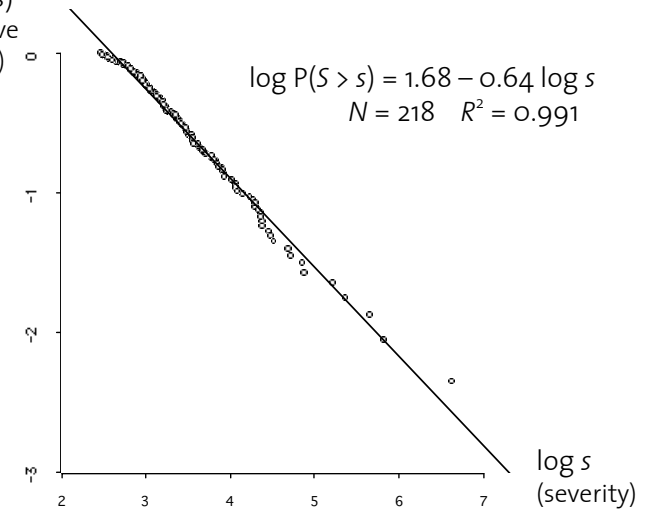


t = 10,000

# Simulated cumulative war-size plot

20

log P(S > s)  
 (cumulative  
 frequency)



See "Modeling the Size of Wars" American Political Science Review Feb. 2003

# Applying Geosim to world politics

Configurations      Processes

Qualitative properties

Example 3.  
Democratic peace

Example 4.  
Emergence of the territorial state

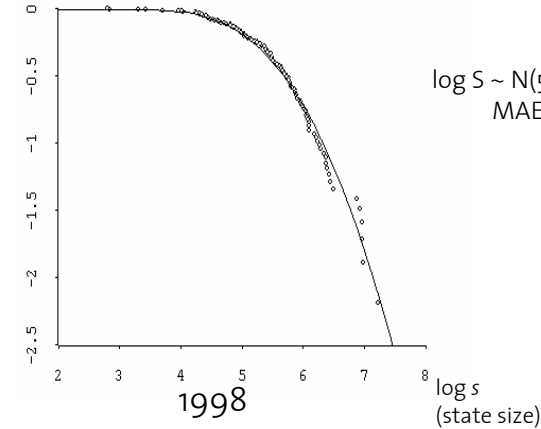
Distributional properties

Example 2.  
State-size distributions

Example 1.  
War-size distributions

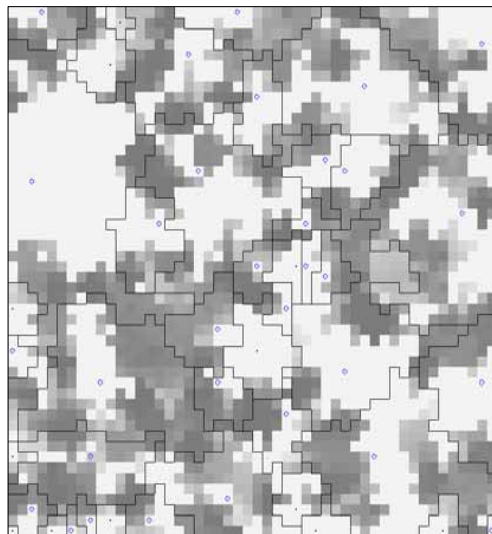
# 2. Modeling state sizes: Empirical data

$\log \Pr(S > s)$   
 (cumulative frequency)



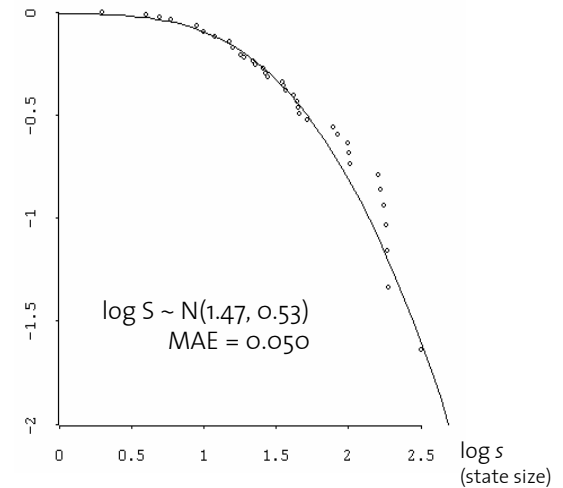
Data: Lake et al.

# Simulating state size with terrain



# Simulated state-size distribution

$\log \Pr(S > s)$   
 (cumulative frequency)



# Applying Geosim to world politics

Configurations      Processes

Qualitative properties

**Example 3.**  
 Democratic peace

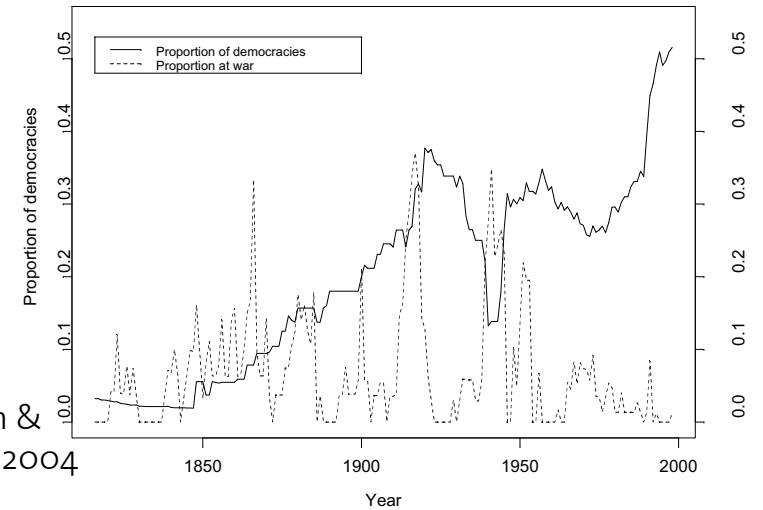
Example 4.  
 Emergence of the territorial state

Distributional properties

Example 2.  
 State-size distributions

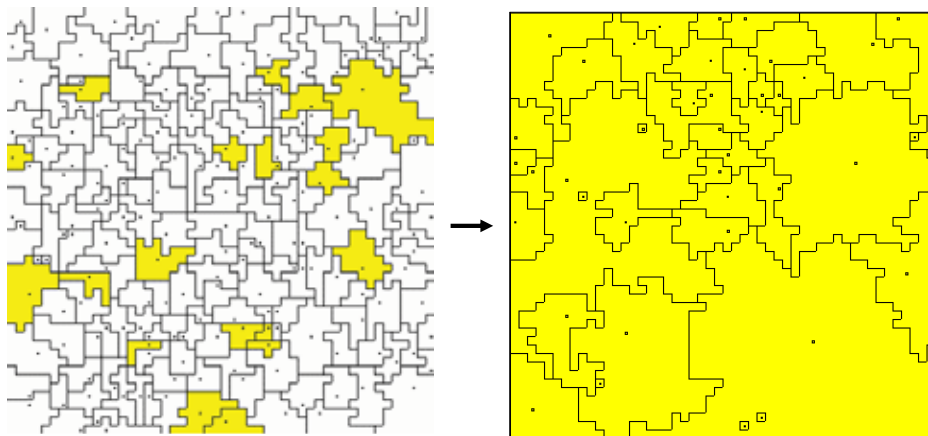
Example 1.  
 War-size distributions

# Simulating global democratization



Source:  
 Cederman &  
 Gleditsch 2004

# A simulated democratic outcome



t = 0

t = 10,000

# Applying Geosim to world politics

Configurations      Processes

Qualitative properties

Example 3.  
 Democratic peace

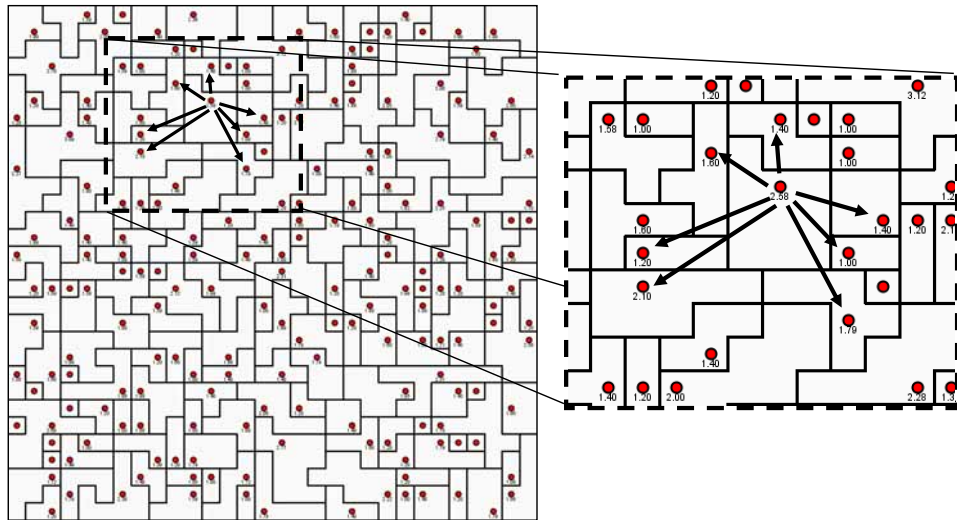
**Example 4.**  
 Emergence of the territorial state

Distributional properties

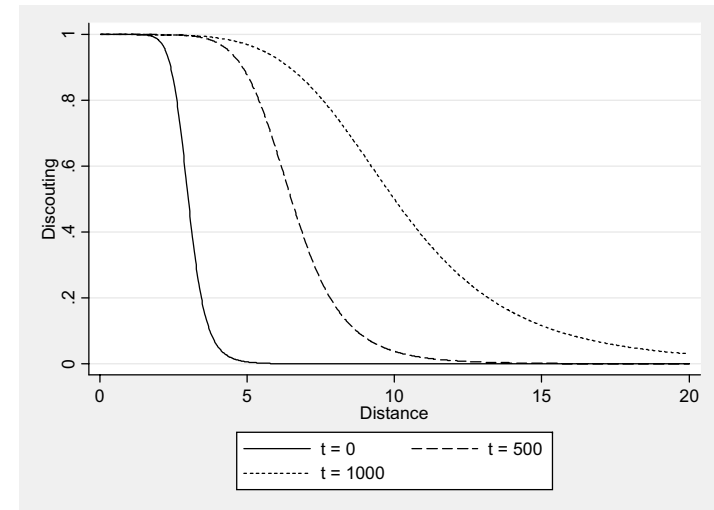
Example 2.  
 State-size distributions

Example 1.  
 War-size distributions

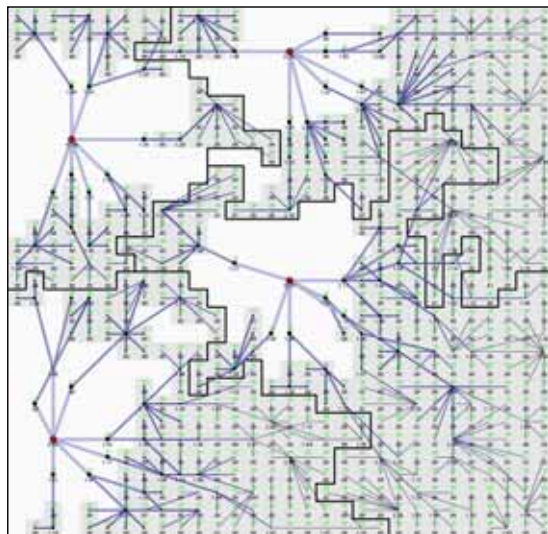
# The initial state of *OrgForms*



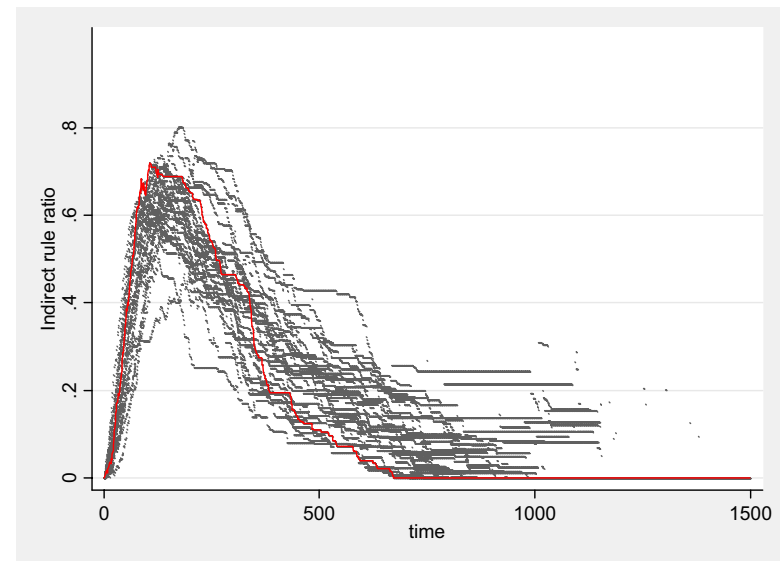
# Modeling technological change



# Indirect rule in the “Middle Ages”

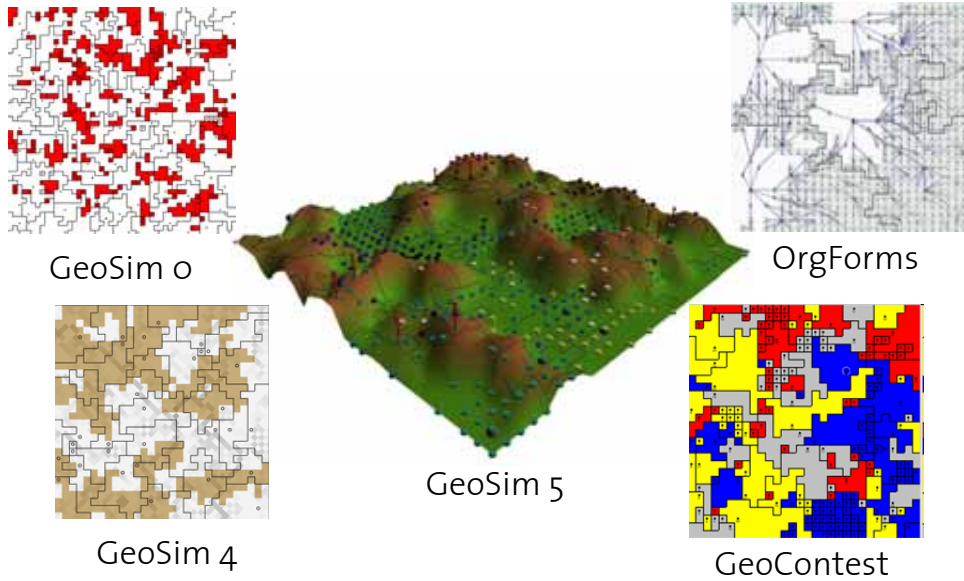


# Replications with moving threshold and slope





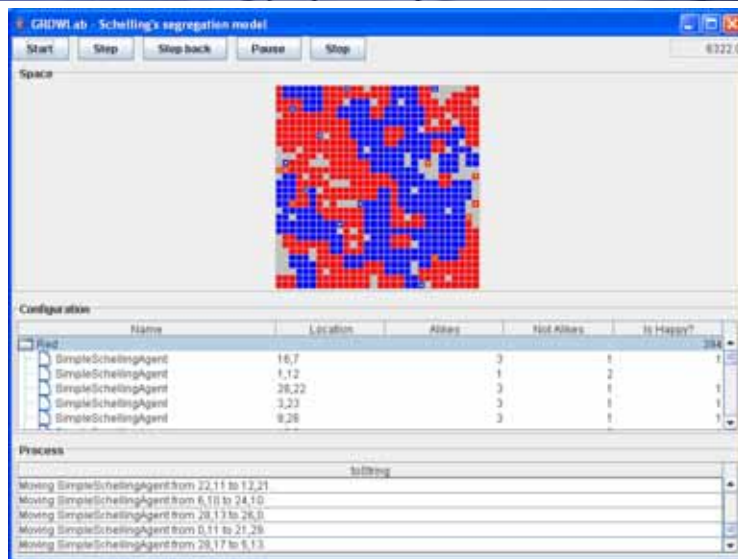
# Exploring geopolitics using agent-based modeling



# GROWLab

- Technical approach
  - Follow same tradition as other toolkits
  - Java based; targeted at programming literates
- Modeling
  - Seeding of the model with empirical facts
  - Simplify the modeling of complex relationships
- Simulation
  - Explicit modeling of processes and behaviors
  - Backtracking
- Analysis
  - Verification
  - Traceable simulation
  - Statistical and visual analysis
  - Validation

# Schelling's segregation model



# Spatial Configurations

