ETH
Eidgenössische Technische Hochschule Zürich
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INTERNATIONAL CONFLICT RESEARCH

Toward a non-equilibrium approach to political violence

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Santa Fe Institute, January 10-12, 2008

Outline

1. From "old" to "new" physics of social phenomena
2. Empirical evidence about conflicts
3. A computational model of interstate warfare
4. New evidence and future challenges

From "old" to "new" physics of social phenomena

Analytical ⇨ Synthetic approach

Equilibrium ⇨ Non-equilibrium theory

Nomothetic ⇨ Generative method

Variable-based ⇨ Configurative ontology

# Analytical ⇨ Synthetic approach

- Hope to solve problems through strategy of "divide and conquer"

- Need to make *ceteris paribus* assumption

- **But** in complex systems this assumption breaks down

- Herbert Simon: Complex systems are composed of large numbers of parts that interact in a non-linear fashion

- Need to study interactions explicitly
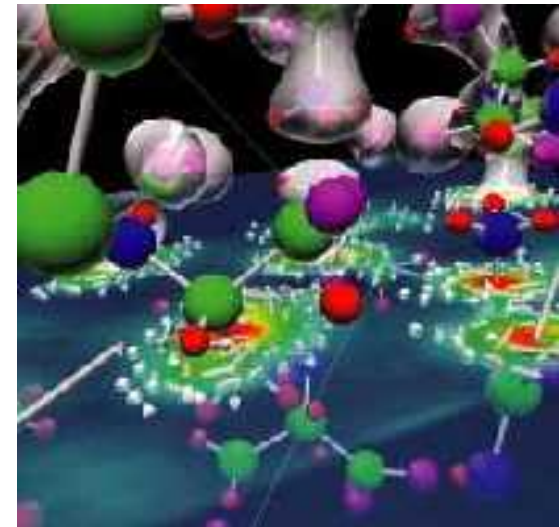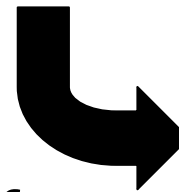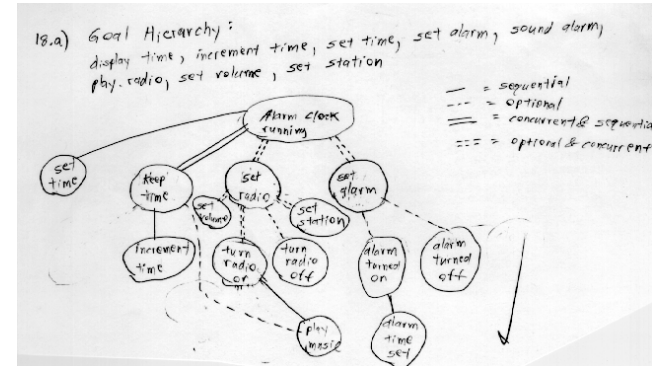
Equilibrium ⇨ Non-equilibrium theory

- Standard assumption in the social sciences: "efficient" history

- **But** contingency and positive feedback undermine this perspective

- Complexity theory and non-equilibrium physics

- Statistical regularities at the macro level despite micro-level contingency
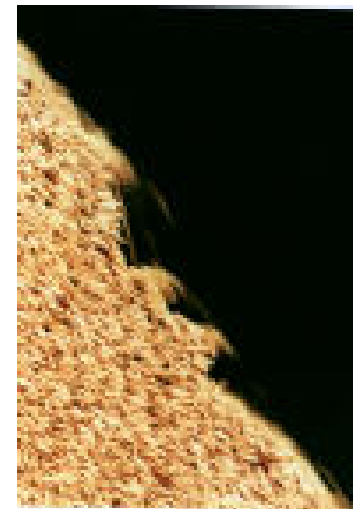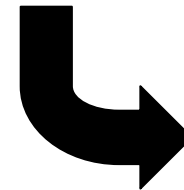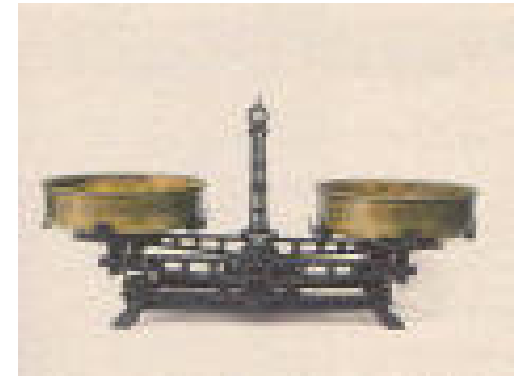
Example: Avalanches in rice pile

Nomothetic ⇨ Generative method

- Search for causal regularities
- Hempel's "covering laws"
- **But** what to do with complex social systems that have few counterparts?
- Scientific realists explain complex patterns by deriving the mechanisms that generate them
- Axelrod: "third way of doing science"
- Epstein: "if you can't grow it, you haven't explained it!"
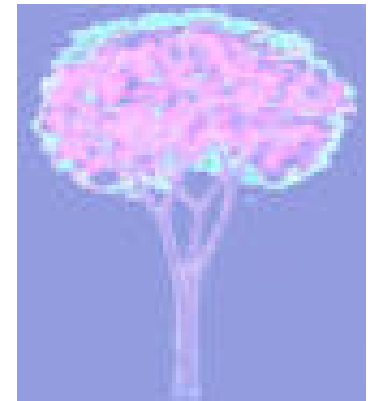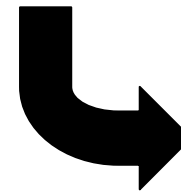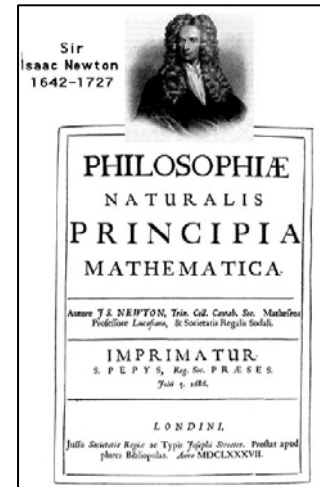
Variable-based ⇨ Configurative ontology

- Conventional models are variable-based
- Social entities are assumed implicitly
- **But** variables say little about social forms
- A *social form* is a configuration of social interactions and actors together with the structures in which they are embedded
- Statistical physics and computational modeling help us endogenizing actors and their interactions explicitly

$$y = a + bx$$

where:

$$a = \frac{\sum y - b \sum x}{n}$$

$$b = \frac{n \sum (xy) - (\sum x)(\sum y)}{n \sum x^2 - (\sum x)^2}$$
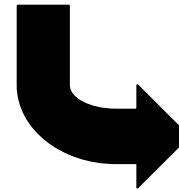
Balance of power and beyond...

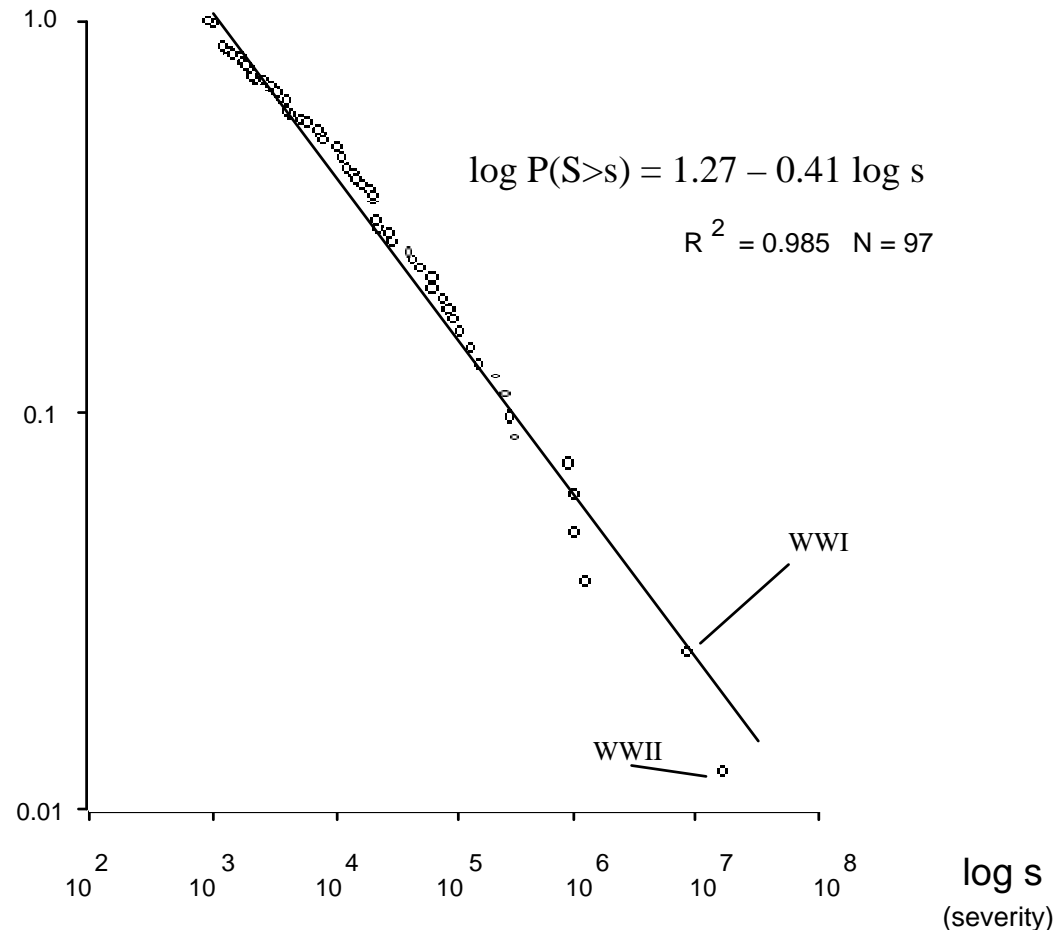*Treaty of Utrecht, 1713*

K. Waltz (static equilibrium approach)

R. Gilpin (dynamic approach)

Cumulative log-log frequency plot, interstate wars 1820-1997
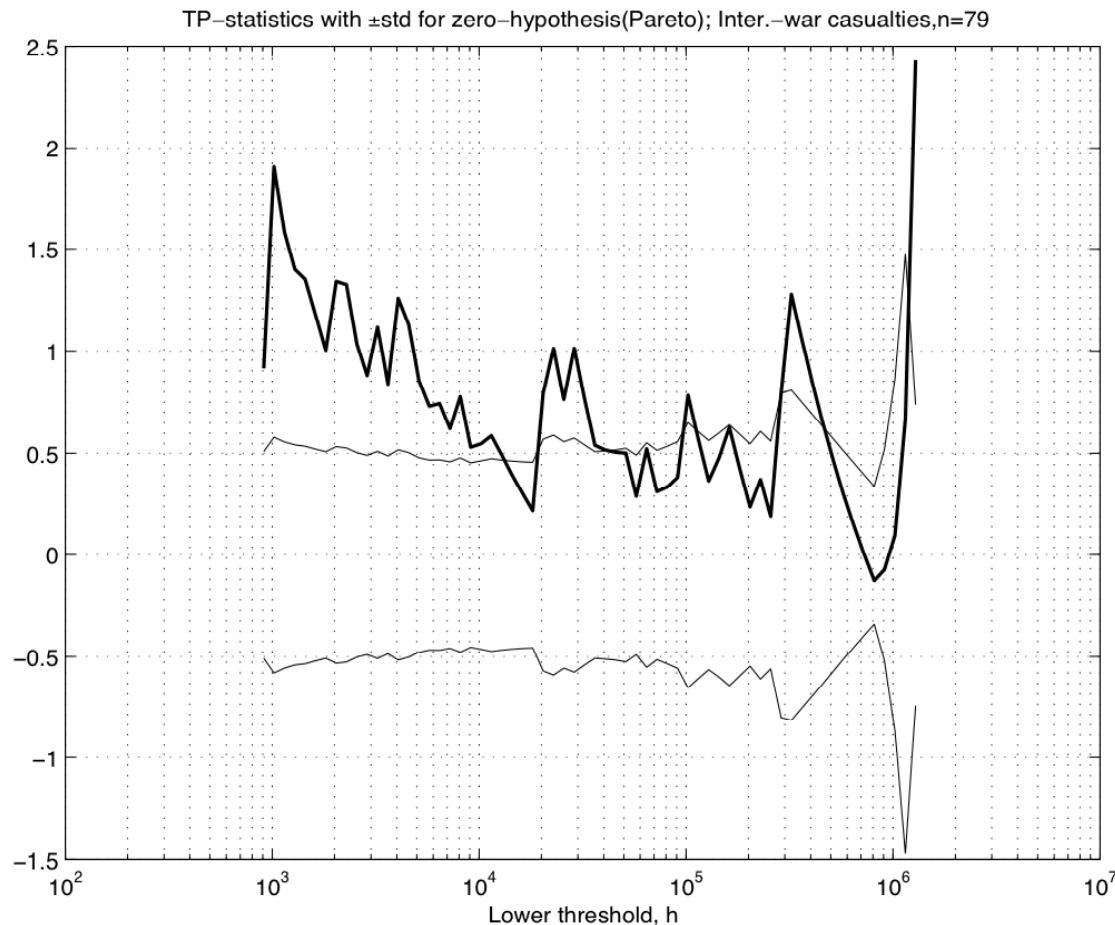
log P(S>s)
(cumulative frequency)

$$\log P(S>s) = 1.27 - 0.41 \log s$$

$$R^2 = 0.985 \quad N = 97$$

Data Source:
Correlates
of War
Project (COW)

See Cederman
APSR 2003

WWI

WWII

log s
(severity)

Interstate war casualties:
Test of upper tail as a function of lower threshold

TP–statistics with ±std for zero–hypothesis(Pareto); Inter.–war casualties,n=79

Data:
COW

Analysis with
Pisarenko &
Sornette

Europe in 1500

Europe in 1900

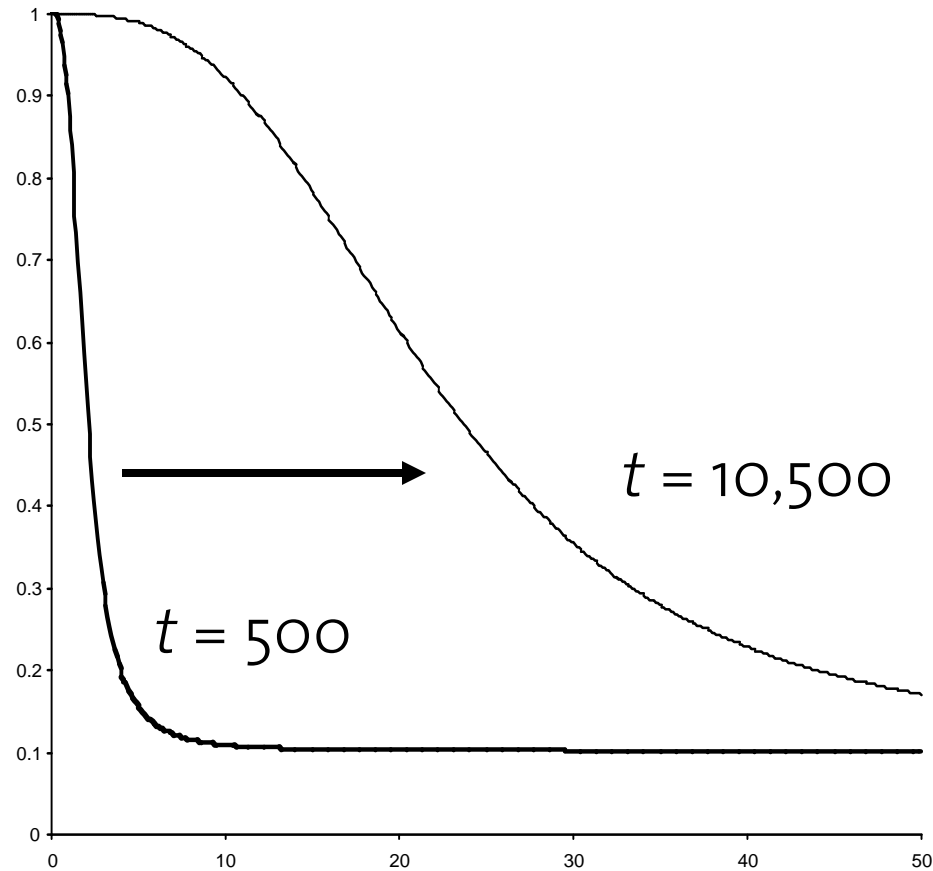# "States made war and war made the state" *Charles Tilly*

Geosim

- Geosim uses Repast, a Java toolkit

- States are hierarchical, bounded actors interacting in a dynamic network imposed on a grid

- *Emergent Actors in World Politics* (PUP 1997)
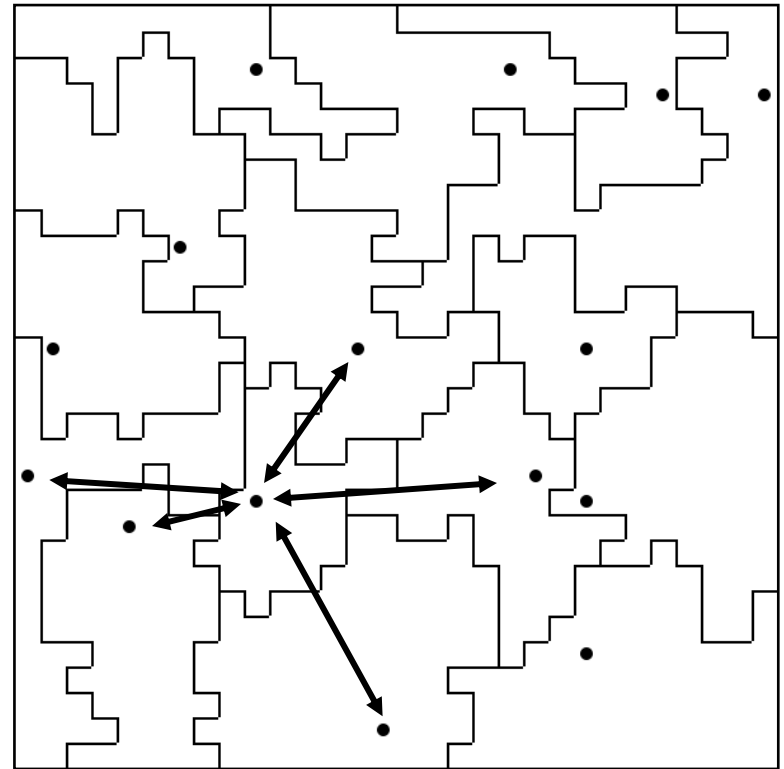
Technological change in terms of the loss-of-strength gradient
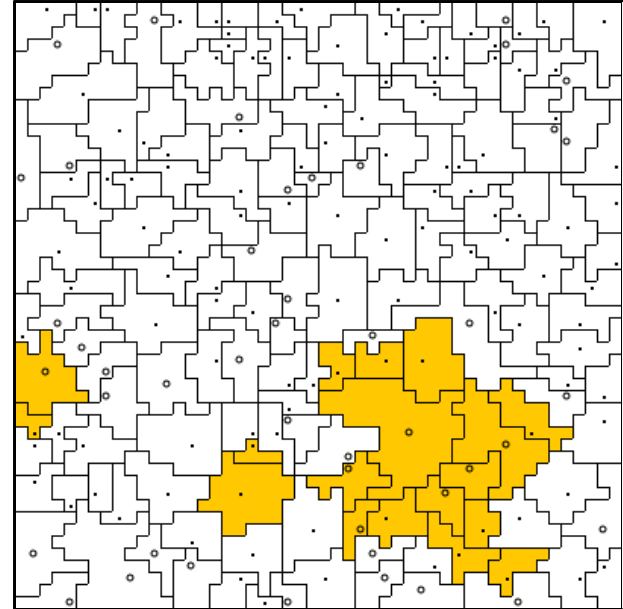
Degree of resource
extraction and projection

$t = 10,500$

$t = 500$

Distance from
capital

Modified Geosim Model
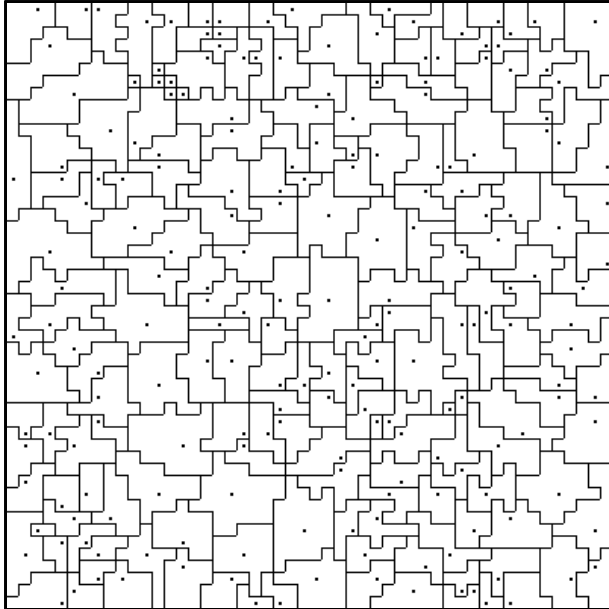
$t = 500$

$t = 3326$

Final outcome
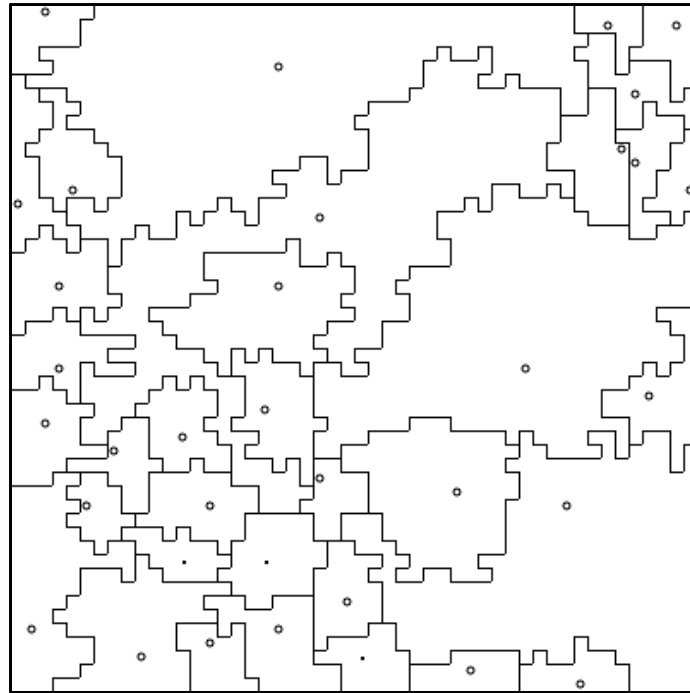
$$t = 10,500$$

Results: Simulated cumulative frequency distribution in the sample run

$\log P(S > s)$

$\log P(S > s) = 1.68 - 0.64 \log s$
$N = 218 \quad R^2 = 0.991$

$\log s$
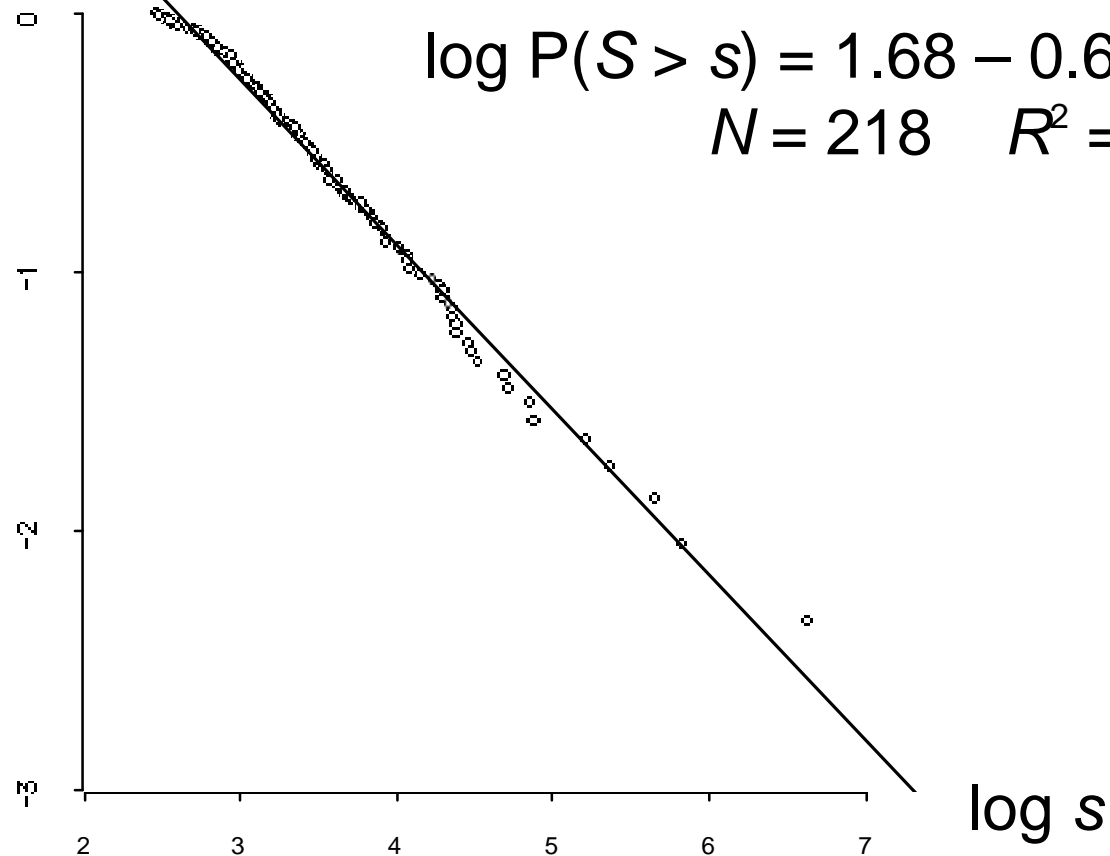
Conclusions from Geosim Model

- First macro model that generates power-law distributed wars

- Technological change + contextual activation

- Non-equilibrium perspective appropriate

- Gilpin rather than Waltz

- Path-dependence doesn't preclude regularities

New evidence and future research

- Nationalism and war size
- Nationalism and state sizes
- Civil wars

Nationalism and warfare

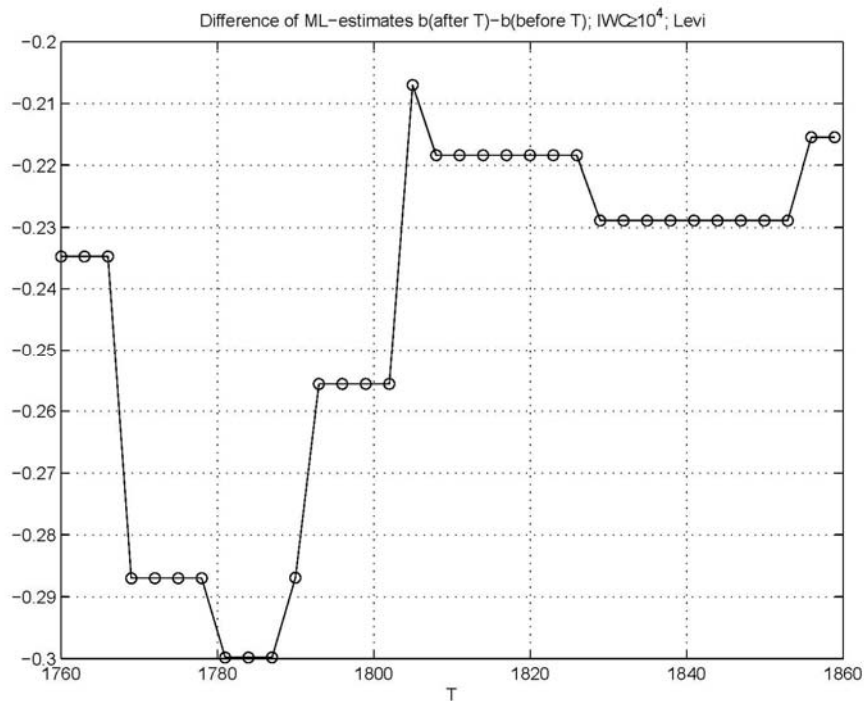*The Battle of Valmy, 20 September 1792*

Trends in war severity, 1500-1970

lg(IWC) in 18−year intervals, smoothed by S−G(−9;+9) filter; Levi; ~1500−1970; n=26

Data:

Levy 1983

Analysis with Pisarenko & Sornette

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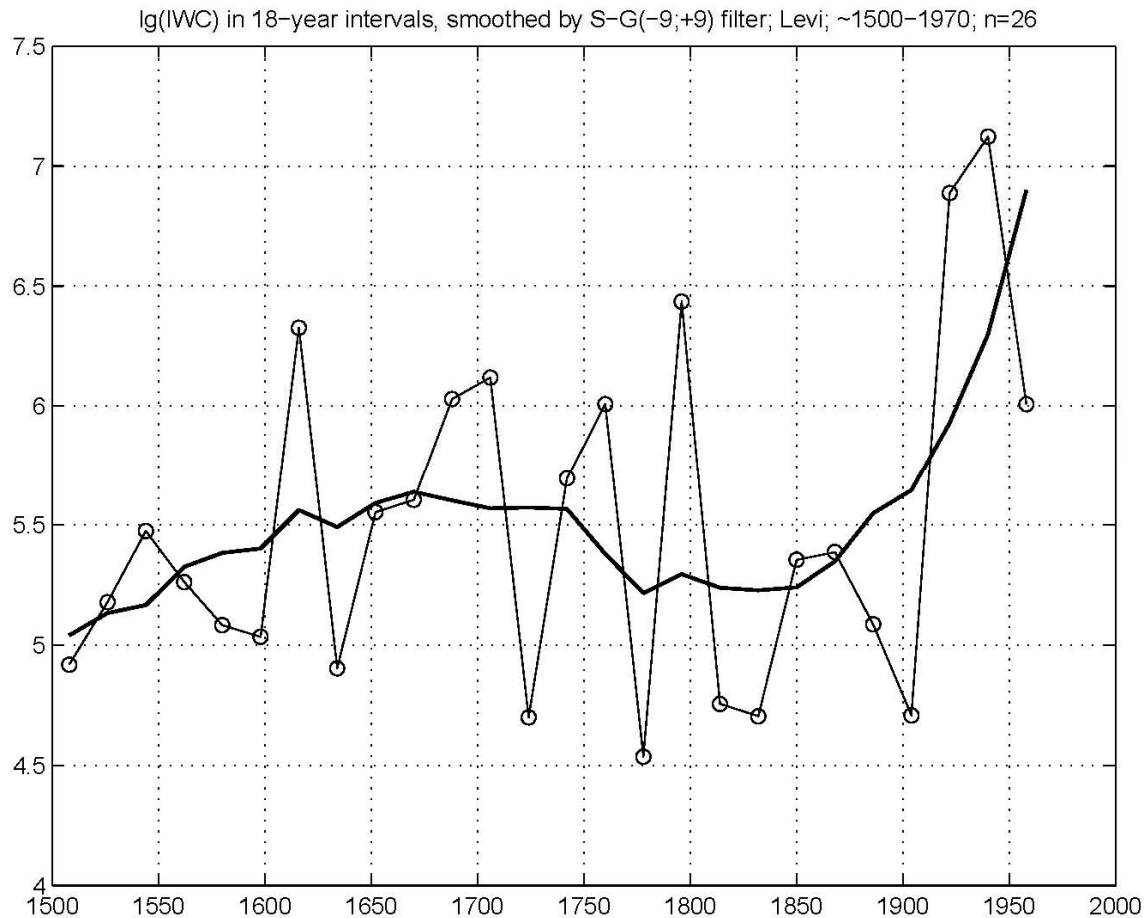
Are there two regimes?

Partitioned MLE

Smirnov statistic for Levy sample
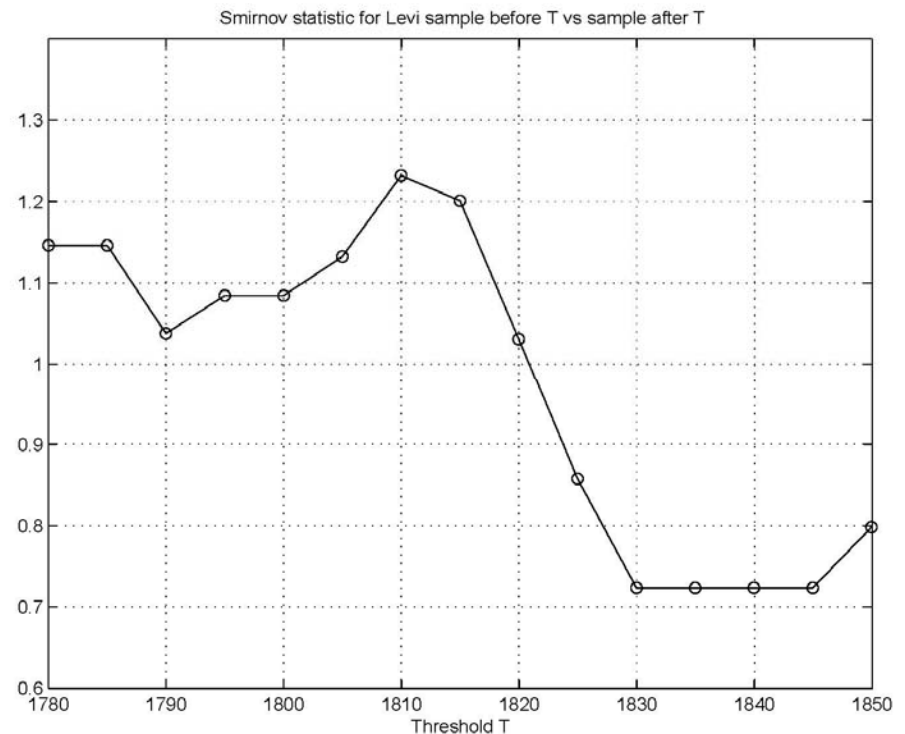
Data: Levy 1983   Analysis with Pisarenko & Sornette

Warfare before and after the French Revolution

log P(S>s)

After 1789:
log P(S>s) = 1.46 – 0.39log s

R^2 = .977

Napoleonic Wars

WWI

Before 1789:
log P(S>s) = 2.67 – 0.69 log s
R^2 = .986

WWII

30 Years' War

log s
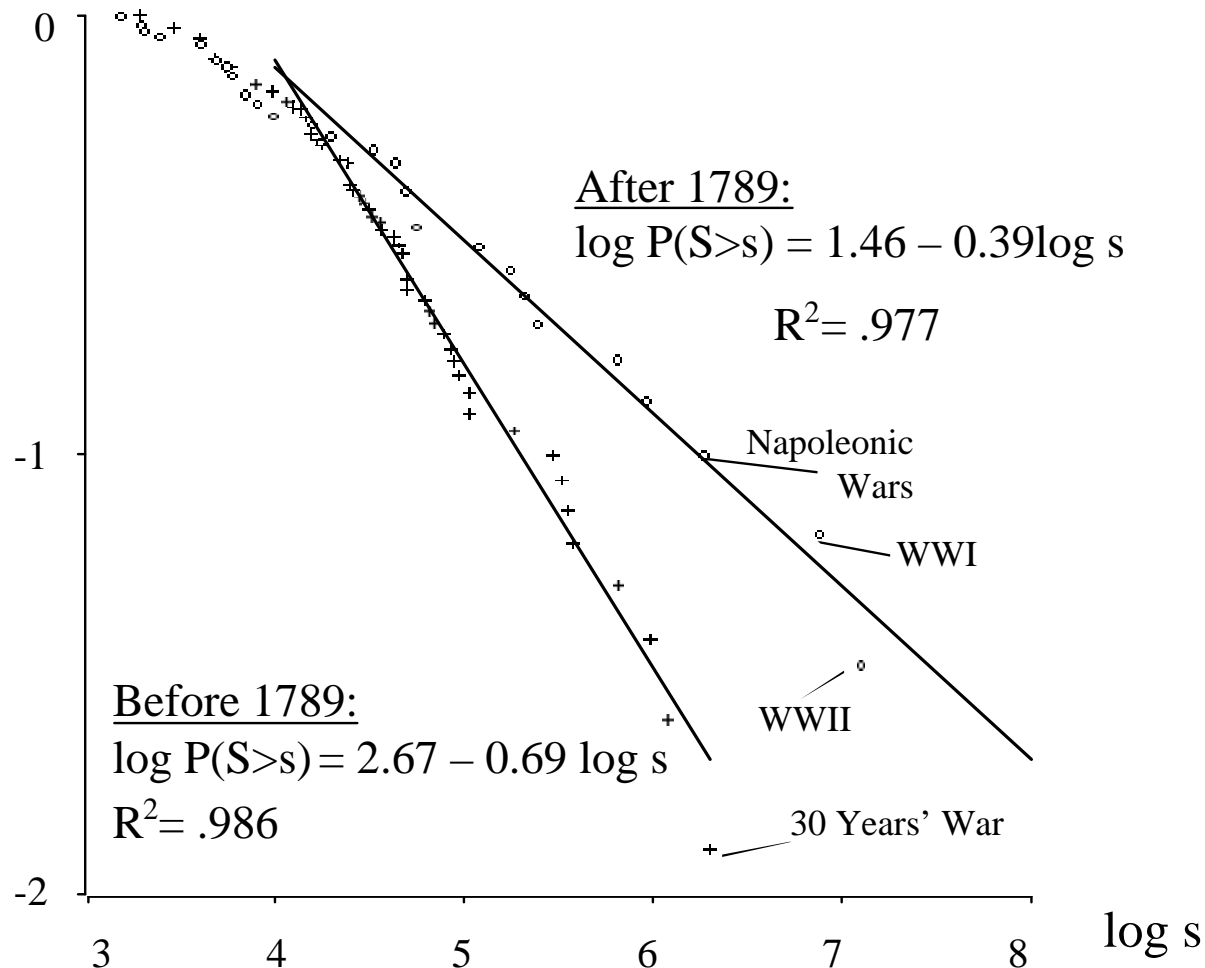
Data:
Levy 1983

Nationalism-based explanations

H_1: Nationalism => Power imbalance => War

Mechanisms:

H_2: Nationalist behavior more risk-willing

H_3: Nationalist resource extraction more effective

H_4: Nationalist mobilization at uneven speeds

H_5: Nationalist secession and unification

Territorial state sizes

log Pr (S > s)

log Pr (S > s)

log S ~ N(4.98, 1.02)
MAE = 0.048

log S ~ N(5.31, 0.79)
MAE = 0.028

1815

1998

log s

log s
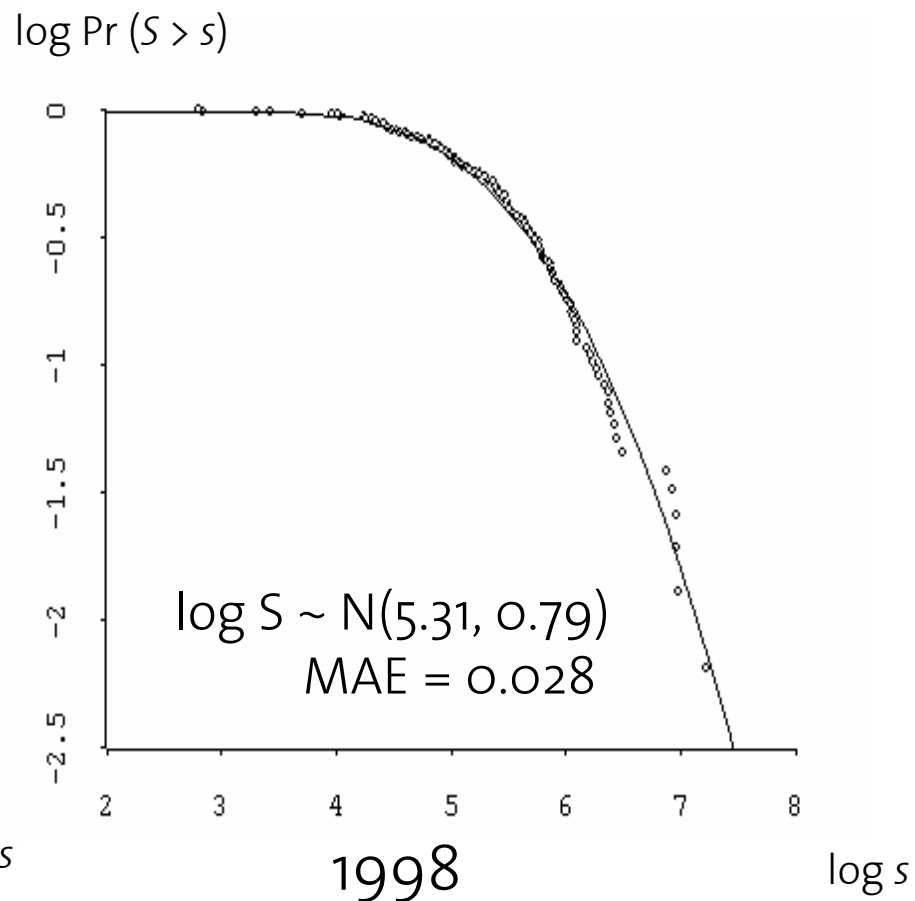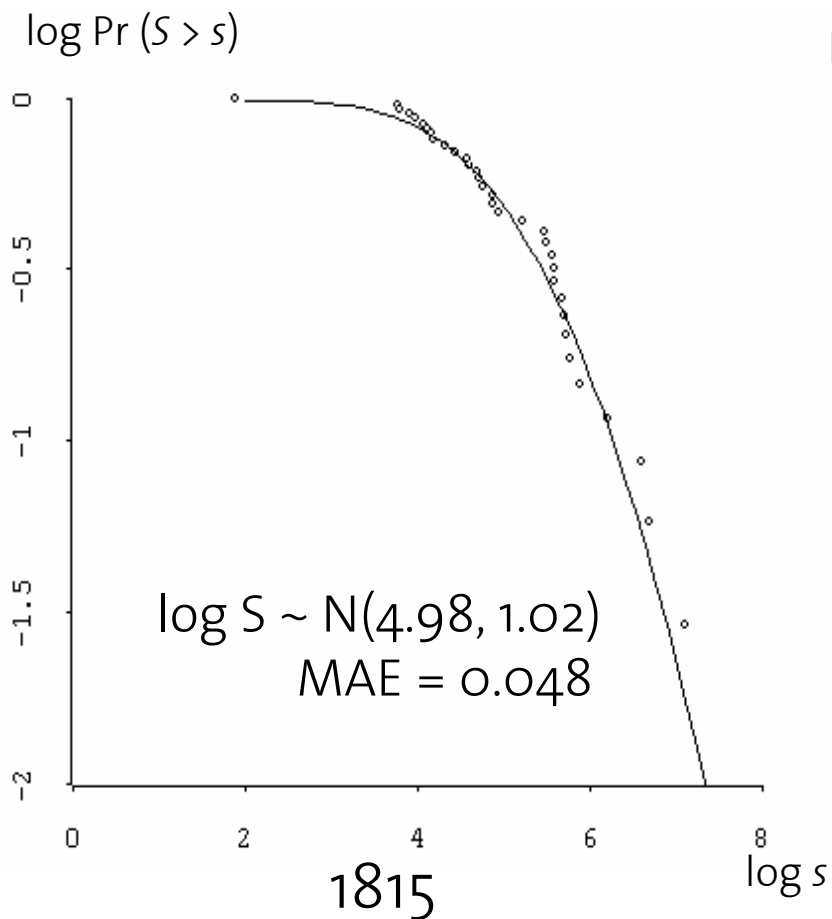
Data: Lake et al.

Estimated means, 1815-1998
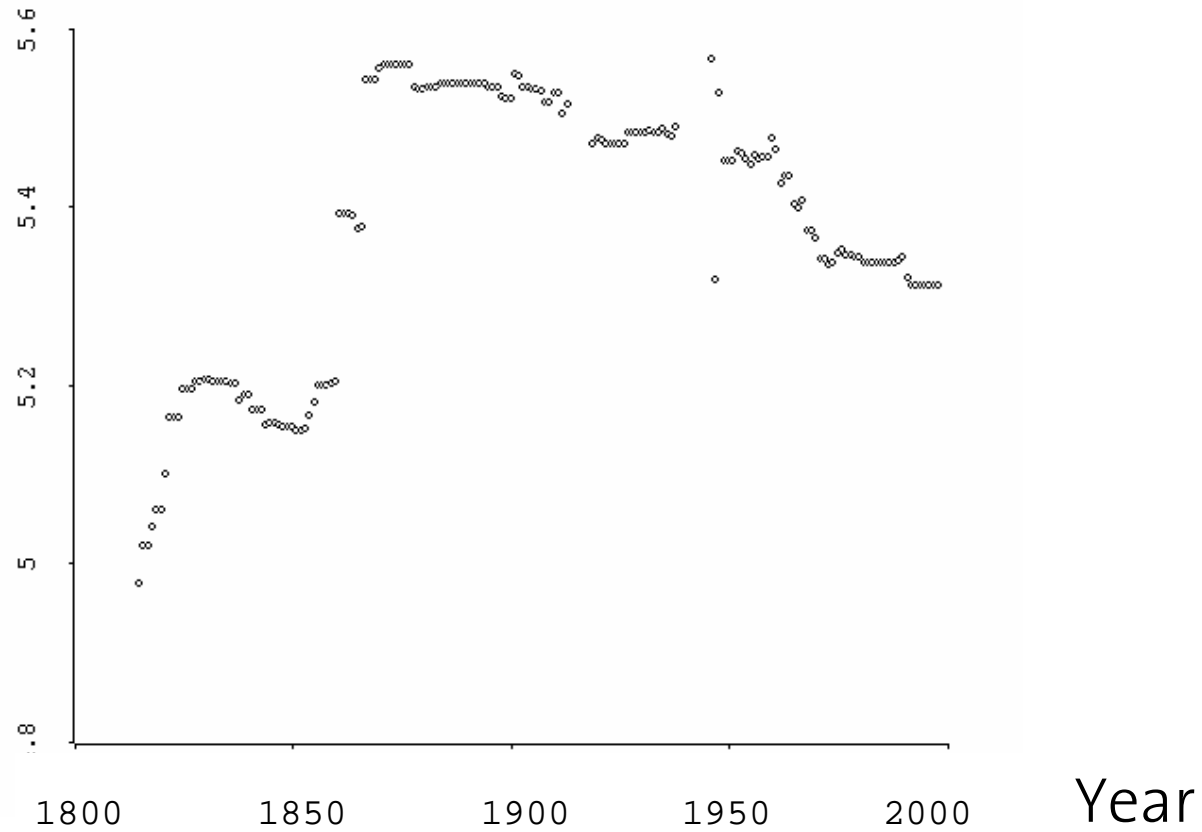
Nested processes
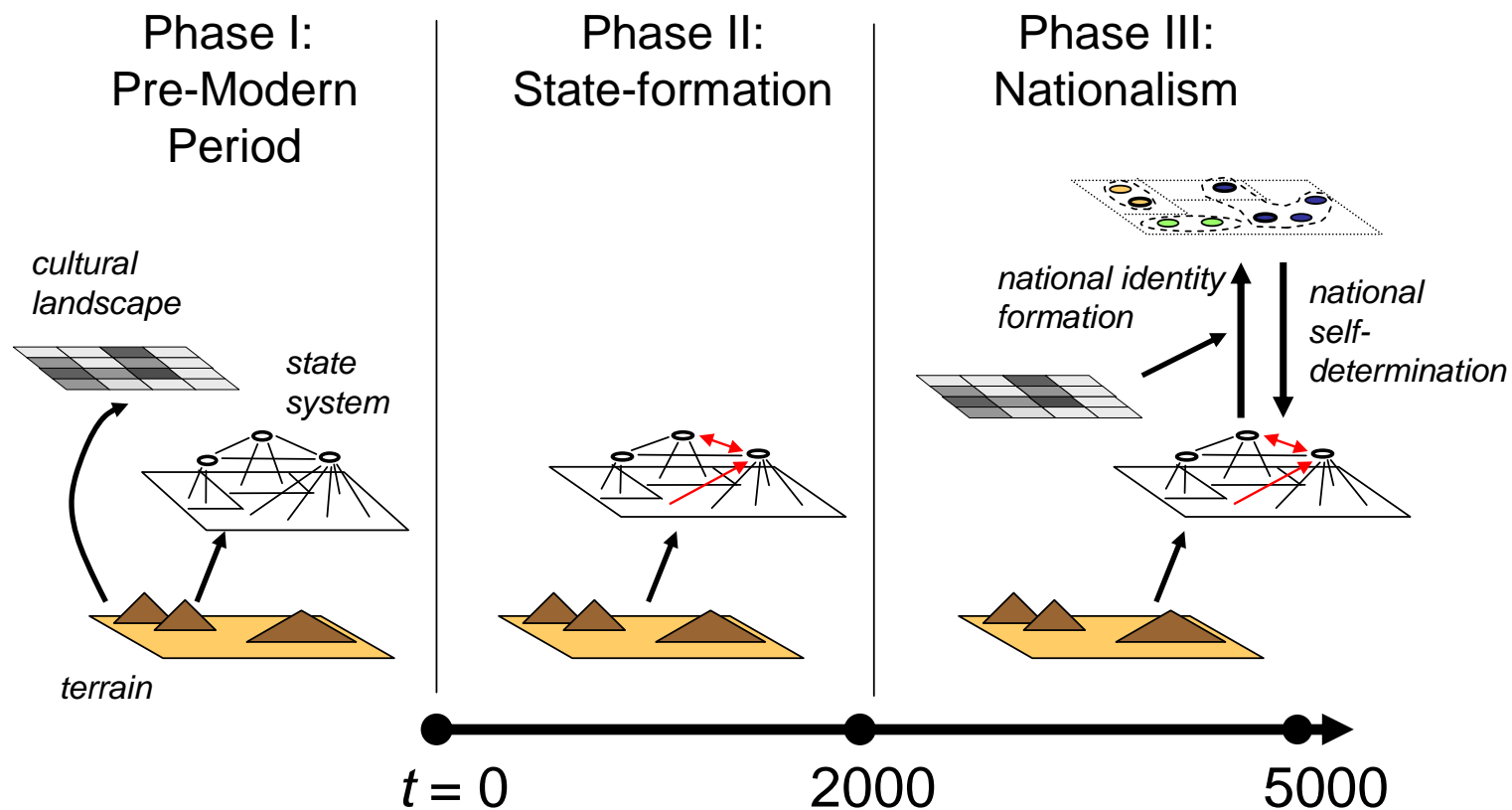
Geosim 5 Model
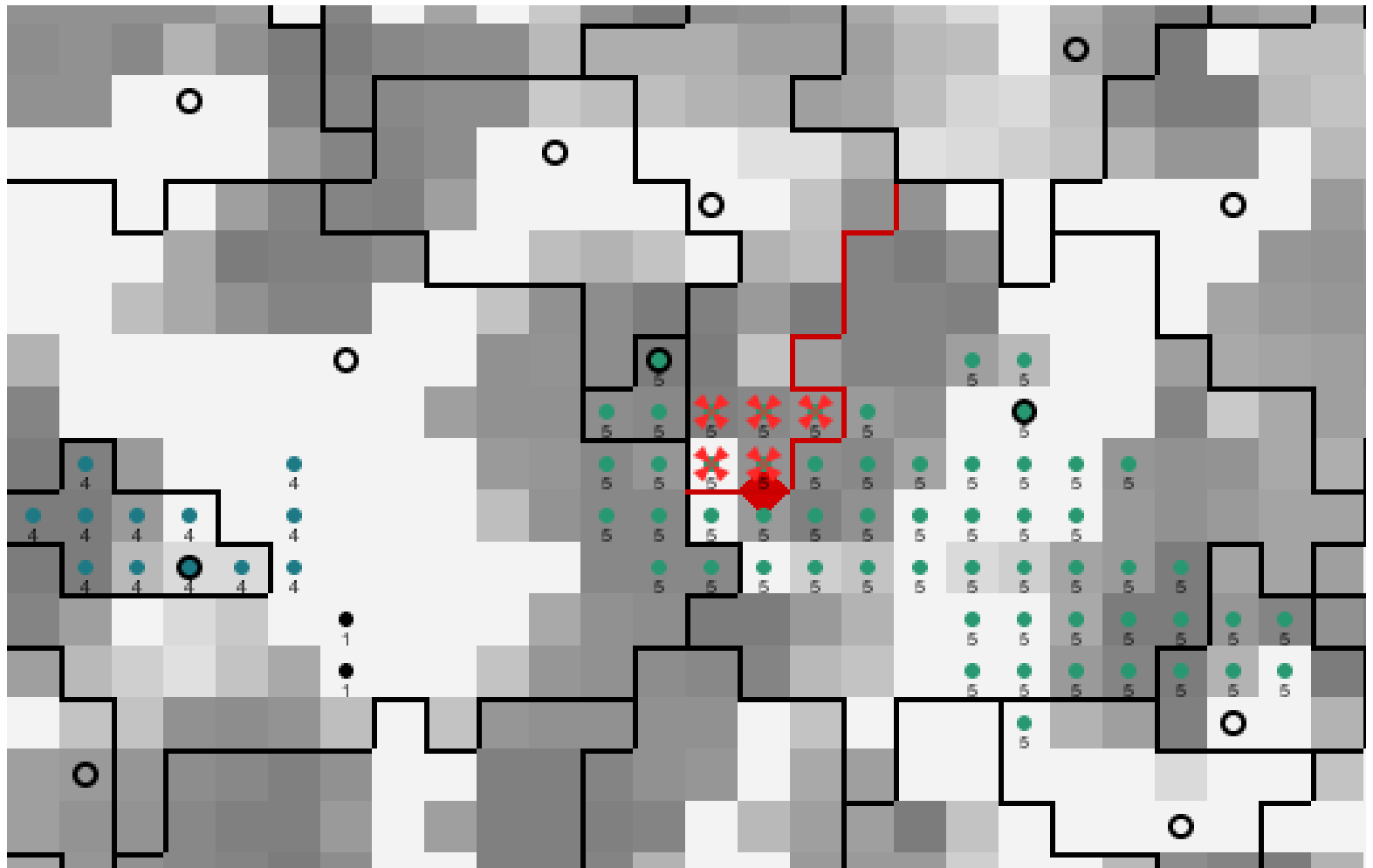
Simulated state sizes fitted by log-normal curve

log Pr(*S>s*)   log Pr(*S>s*)

log *S* ~ N(1.41, 0.10)
MAE = 0.046

log *S* ~ N(1.28, 0.09)
MAE = 0.040
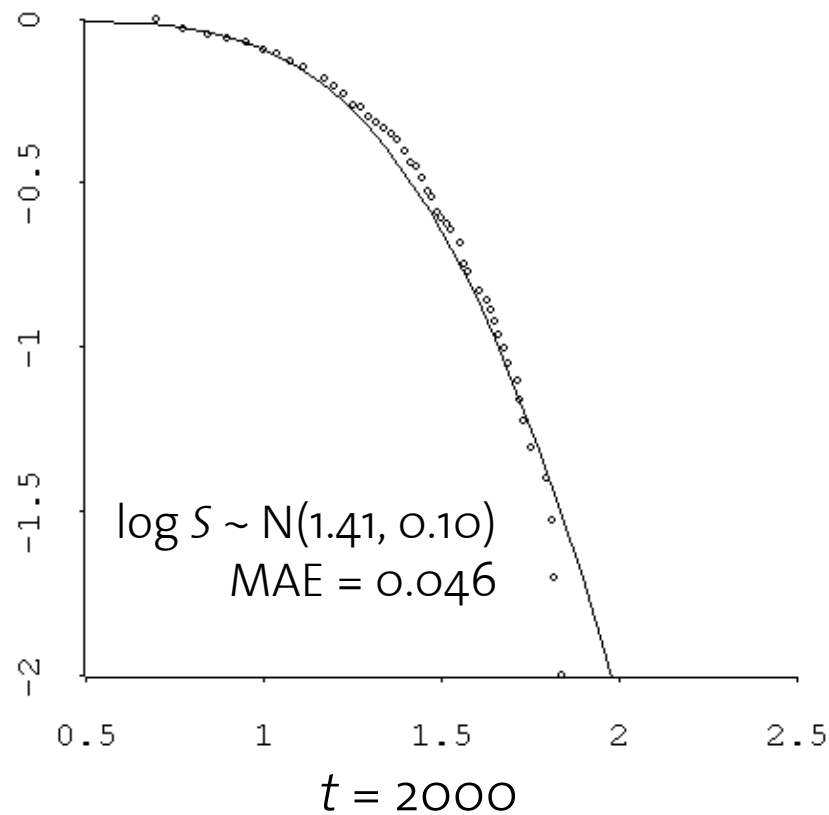
t = 2000   log *S*   *t* = 5000   log *S*
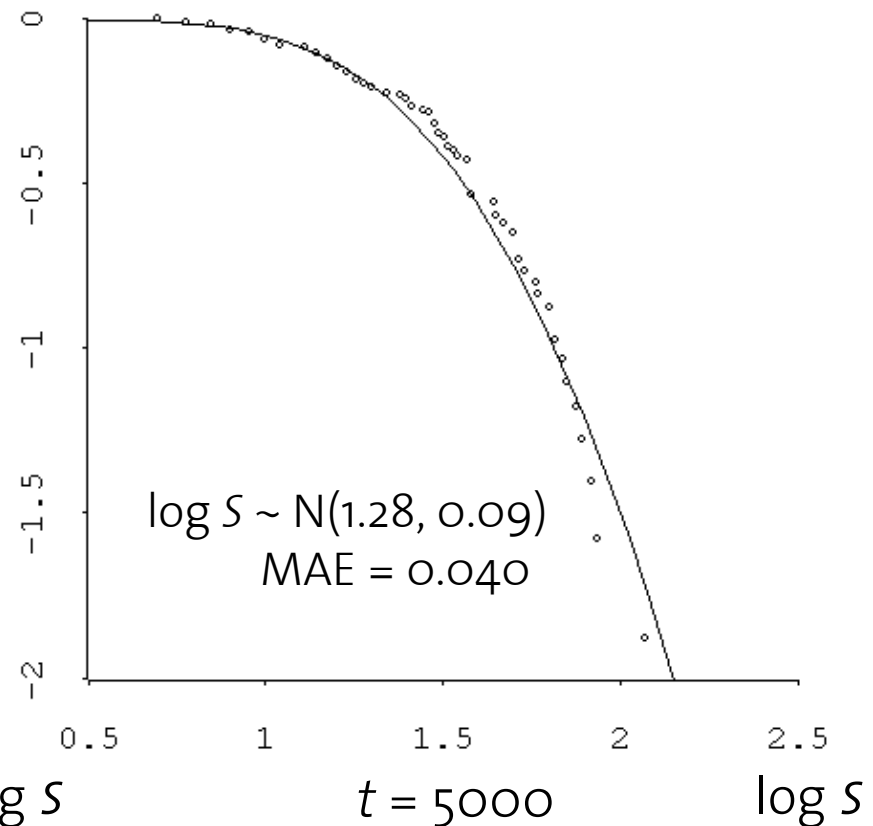
Civil war casualties
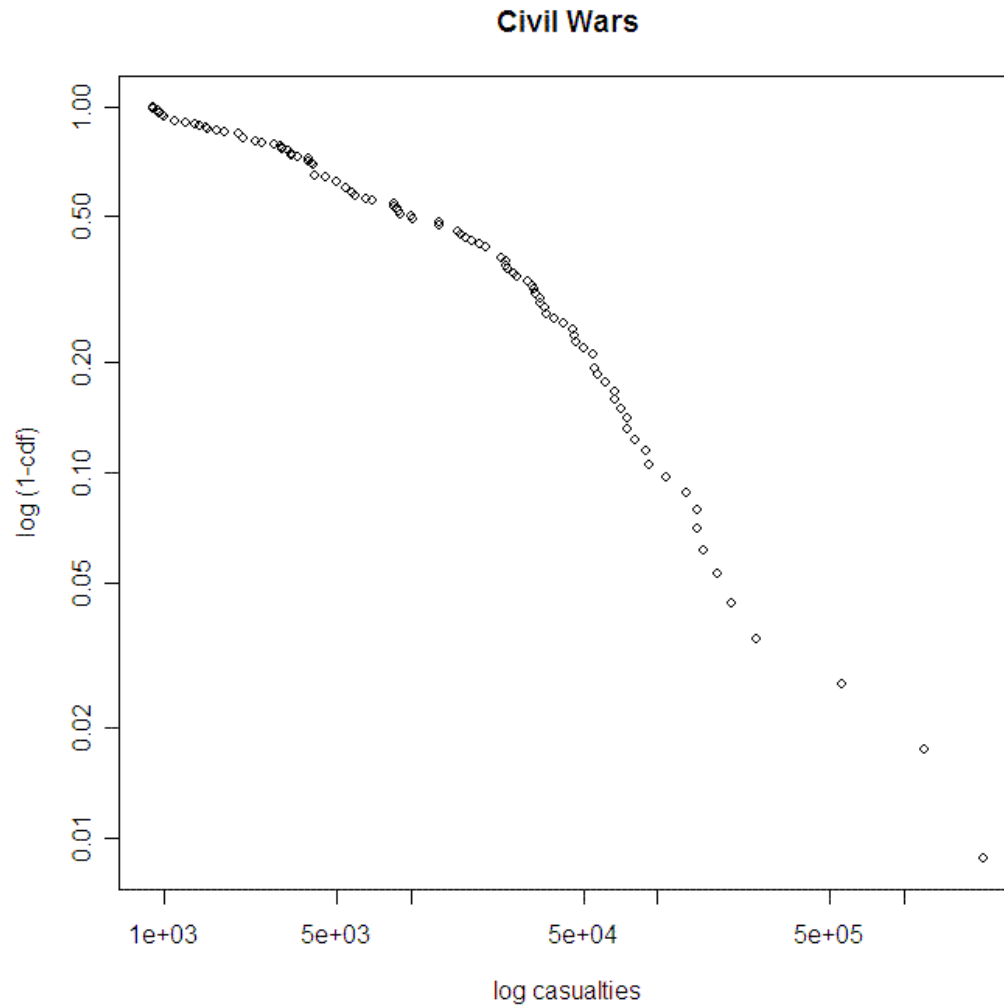
Source:

Lacina 2006

Civil war casualties:
Test of upper tail as a function of lower threshold

TP–statistics with±std for Pareto; CWC, n=114
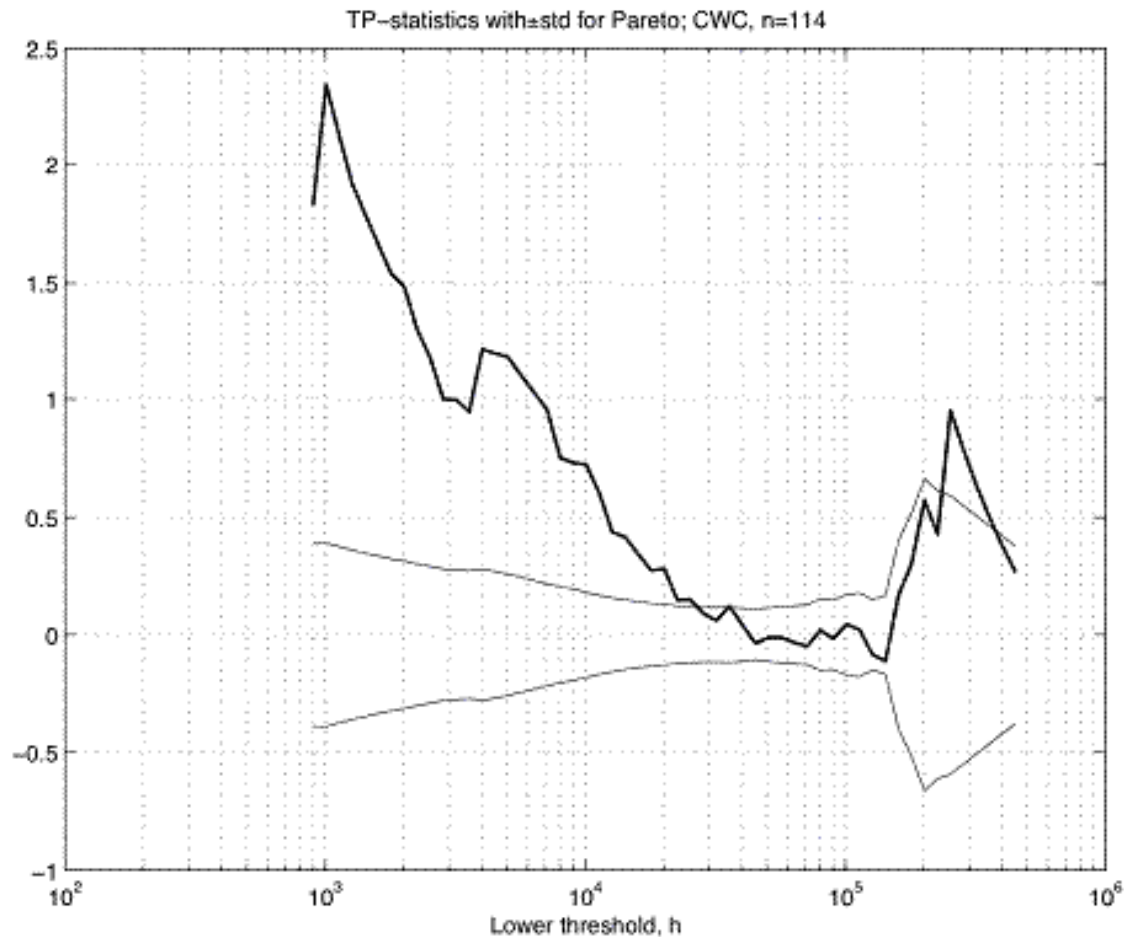
Analysis with Pisarenko & Sornette

Exploring geopolitics using agent-based modeling
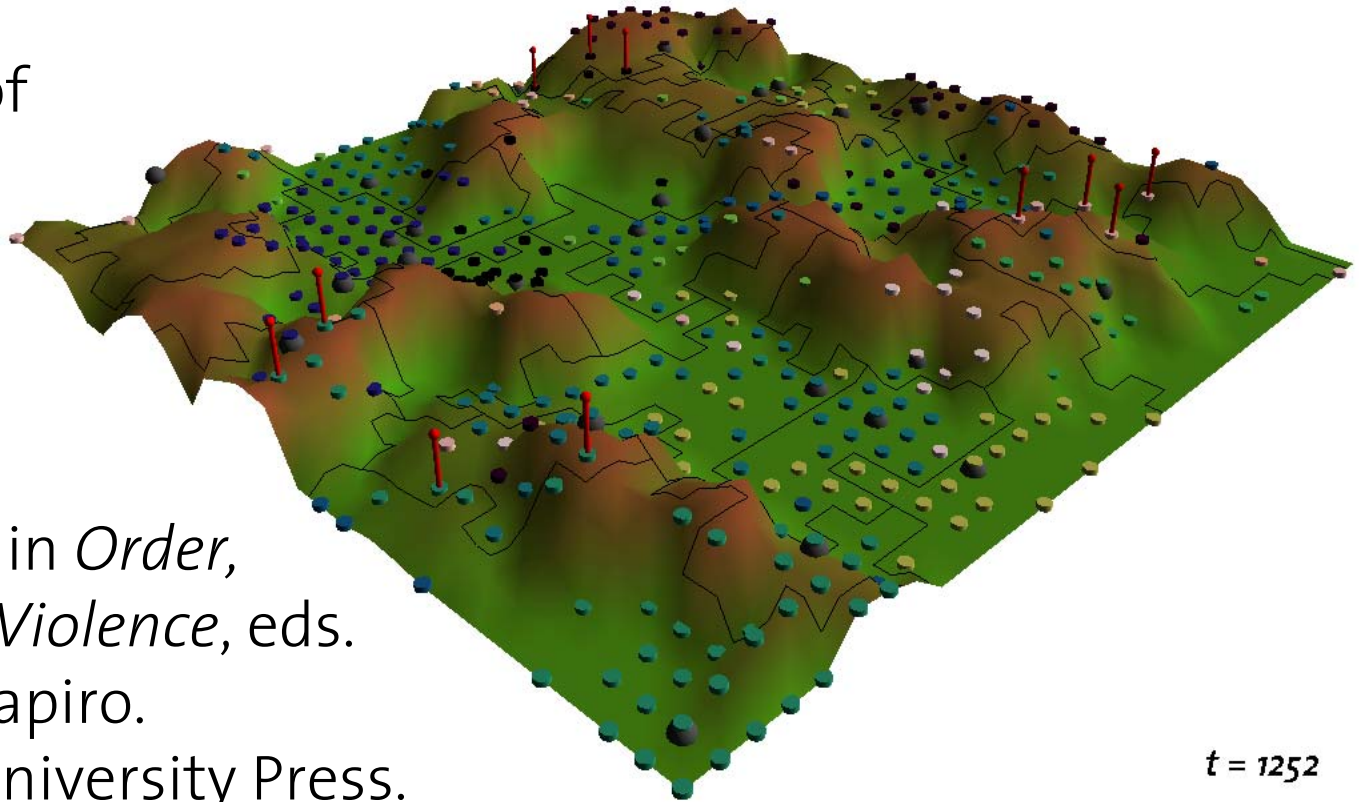

GeoSim 0
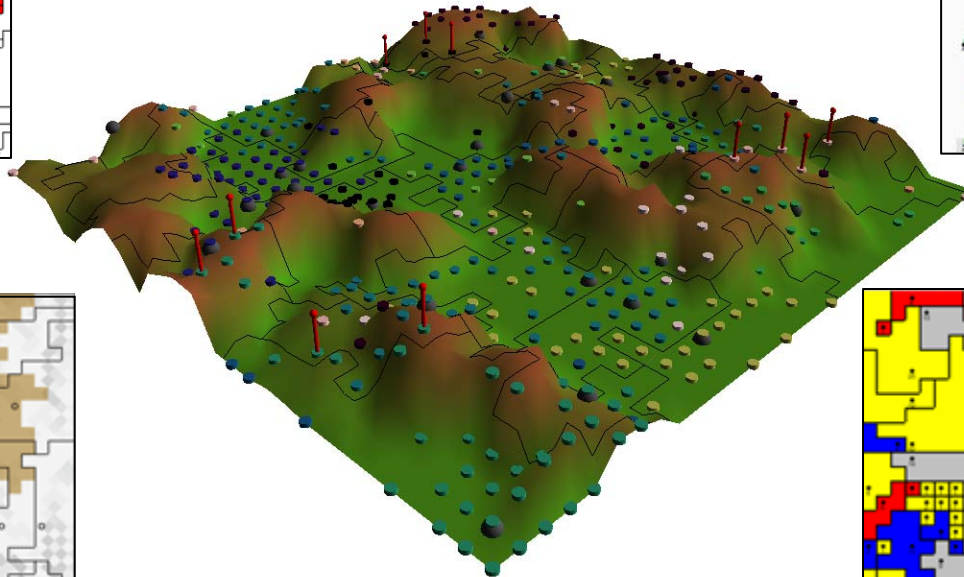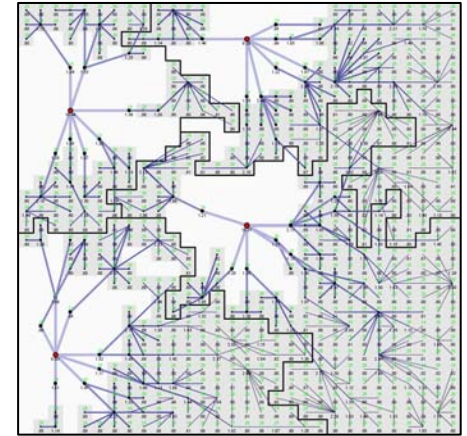
OrgForms
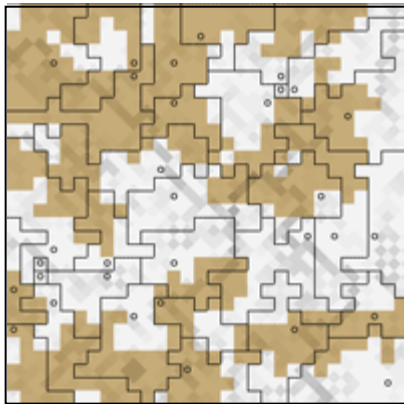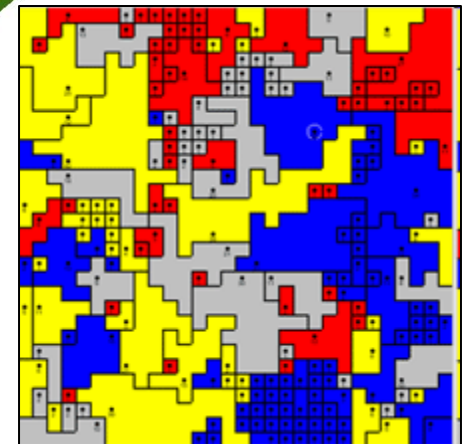
GeoSim 4

GeoSim 5

GeoContest

Toward more realistic models of civil wars

- Our strategy:
  - Step I: extending Geosim framework
  - Step II: conducting empirical research
  - Step III: back to computational modeling

Step I: Nationalist insurgency model

Use agent-based modeling to articulate identity-based mechanisms of insurgency

Forthcoming in *Order, Conflict, and Violence*, eds. Kalyvas & Shapiro. Cambridge University Press.

t = 1252

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Step II: GREG
Geo-Referencing of Ethnic Groups

- Scanning and geo-coding ethnic groups

- Polygon representation

- Based on *Atlas Narodov Mira* (1964)

Step II: ESEG Expert Survey of Ethnic Groups

Collaboration with Andreas Wimmer and Brian Min (UCLA)

Web-based interface in order to expand coding of politically relevant ethnic groups and their power access to the rest of the world with the help of area experts

Step III: GROWLab