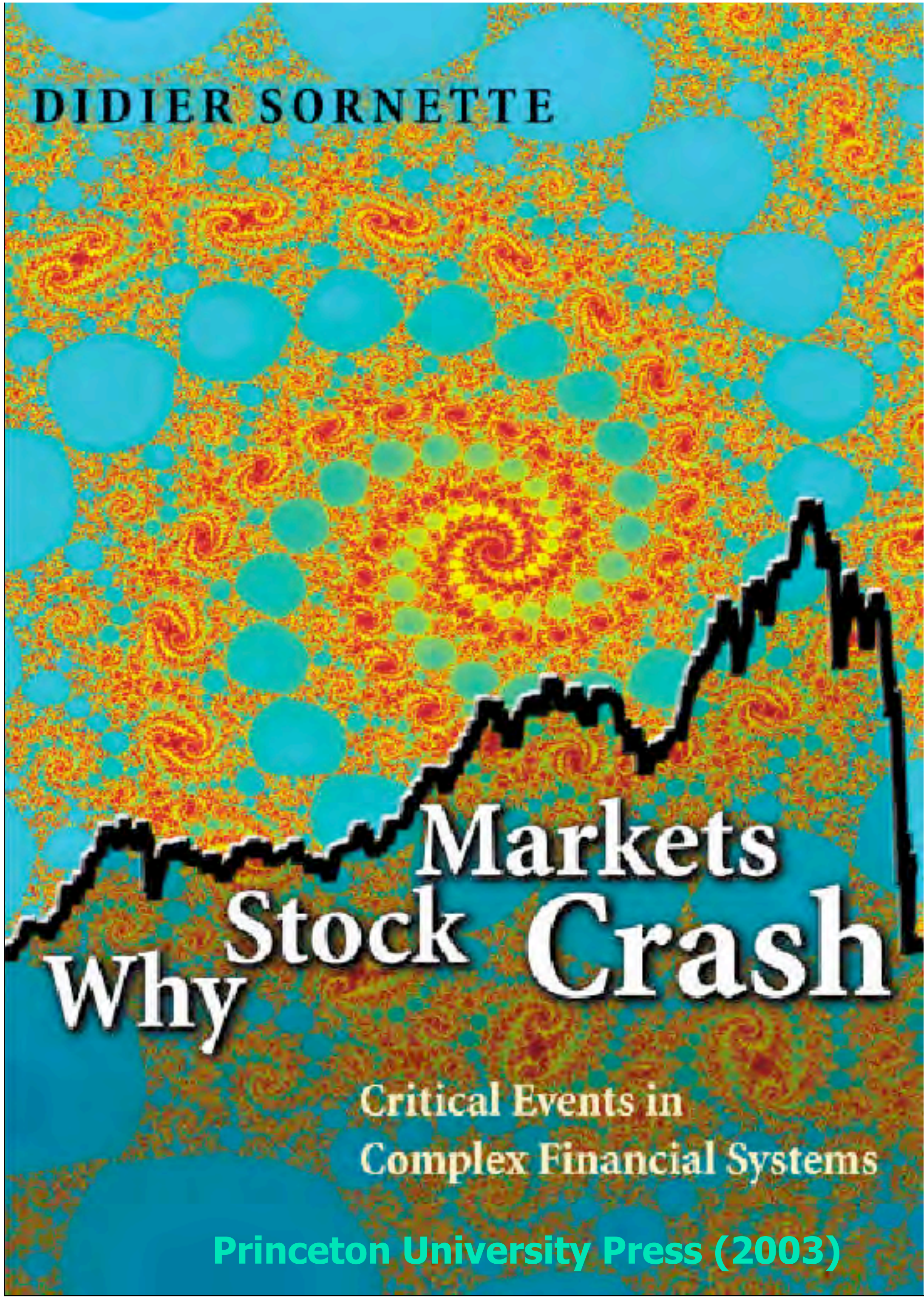


KINGS and PREDICTION

Department of Management, Technology and Economics, ETH Zurich, Switzerland

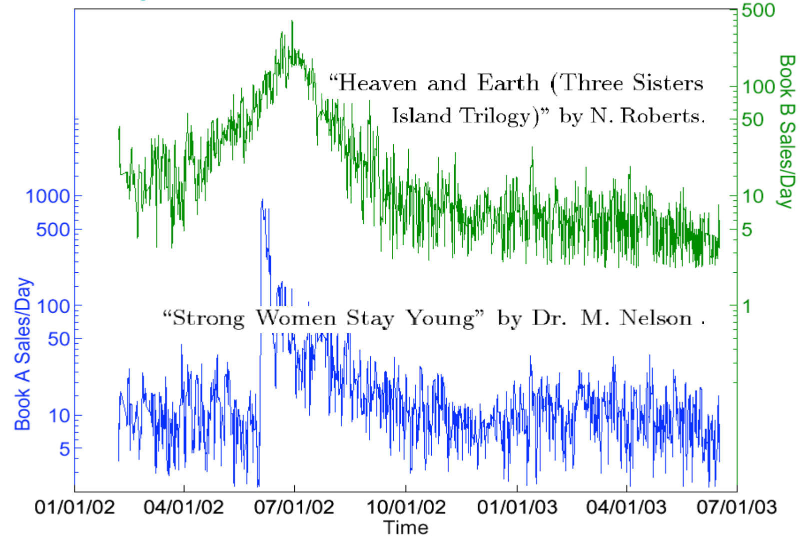
Member of the Swiss Finance Institute

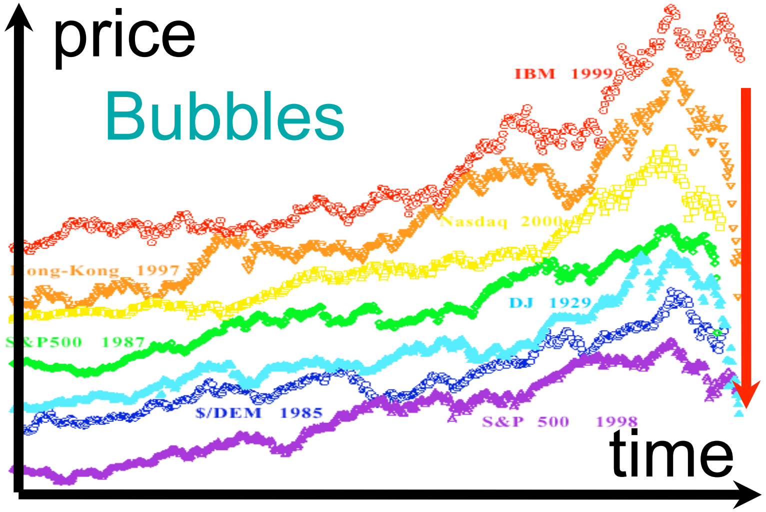
co-founder of the Competence Center for Coping with Crises in Socio-Economic Systems, ETH Zurich (http://www.ccss.ethz.ch/)

long-term Collaborators:
Y. Ageon (Insight Finance, France)
J. Andersen (CNRS, France)
D. Darcet (Insight Research)
K. Ide (UCLA)
A. Johansen (Denmark)
Y. Malevergne (Univ. Lyon, France)
V: Pisarenko (Acad. Sci. Moscow, Russia)
W.-X. Zhou (UCLA, now at Shanghai)
more recent collaborators:
G. Harras (ETH Zurich)
T. Kaizoji (Tokyo)
A. Saichev (ETH Zurich and Nizhny Novgorod)
R. Woodard and H. Woodard (ETH Zurich)
W. Yan (ETH Zurich)
A. Huesler (ETH Zurich)
M. Fedorovsky (ETH Zurich)
S. Reimann (ETH Zurich)

- Collective dynamics and organization of social agents (Commercial sales,YouTube, Open source softwares, Cyber risks)
- Agent-based models of bubbles and crashes, credit risks, systemic risks
- Prediction of complex systems, stock markets, social systems
- Asset pricing, hedge-funds, risk factors…
- Human cooperation for sustainability
- Natural and biological hazards (earthquakes, landslides, epidemics, critical illnesses…)

Dynamics of success





(3 guest-professors, 5 foreign associate professors,
3 post-docs, 2 senior researcher, 12 PhD students, 4-6 Master students)

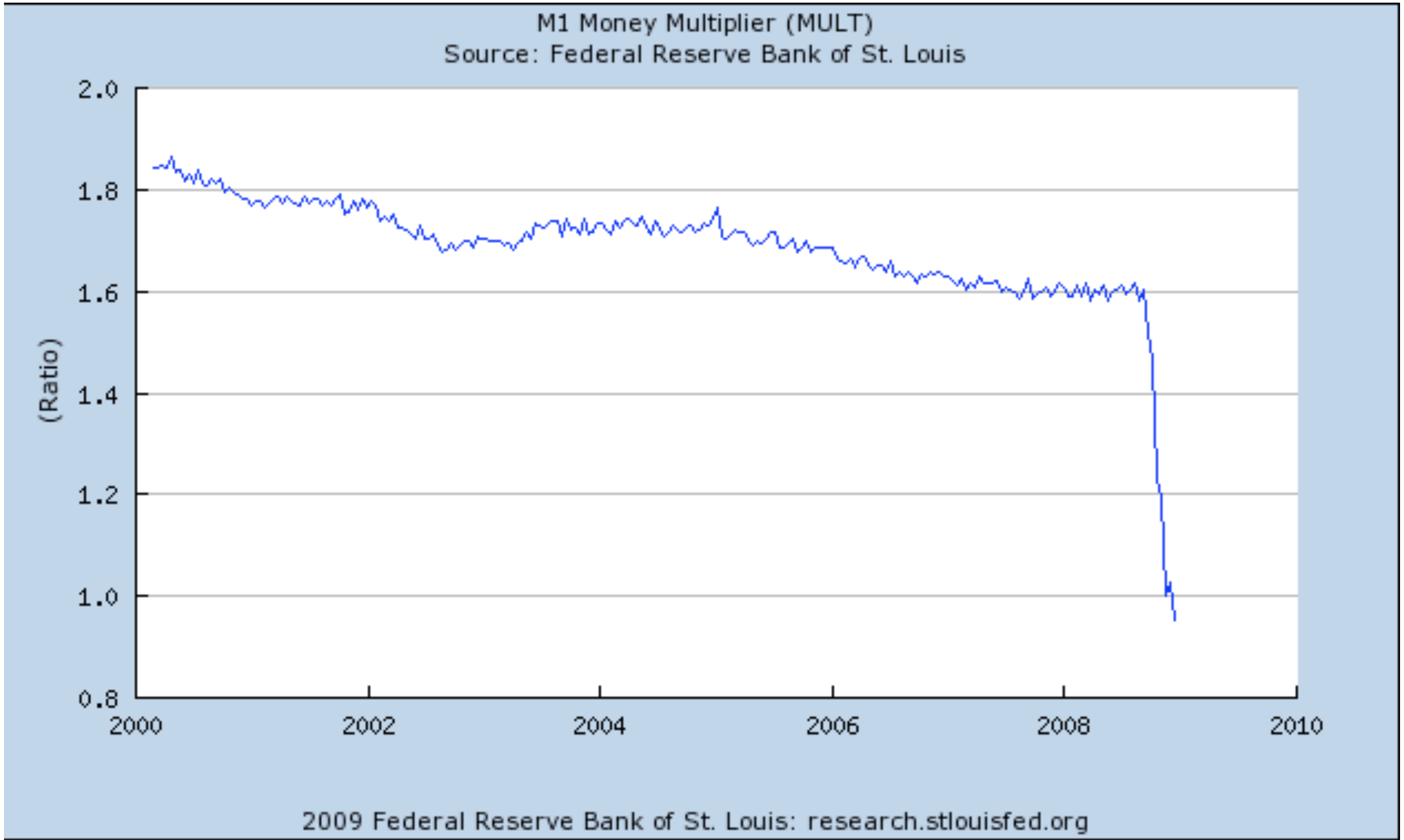
CRISES and EXTREMES

Non-Borrowed Reserves of Depository Institutions (BOGNONBR) continue to plummet. This makes sense as under capitalized banks continue to hemorrhage money via outright losses and write downs of over valued assets. The result is that these banks now have to borrow money from the Fed to maintain their reserves so that when you go to the ATM money actually comes out...

This also explains why all interbank lending rates from LIBOR and EURIBOR to HIBOR all did moonshots. You see, there were few banks capable of lending in any size, and even fewer willing.

MONDAY, JANUARY 05, 2009

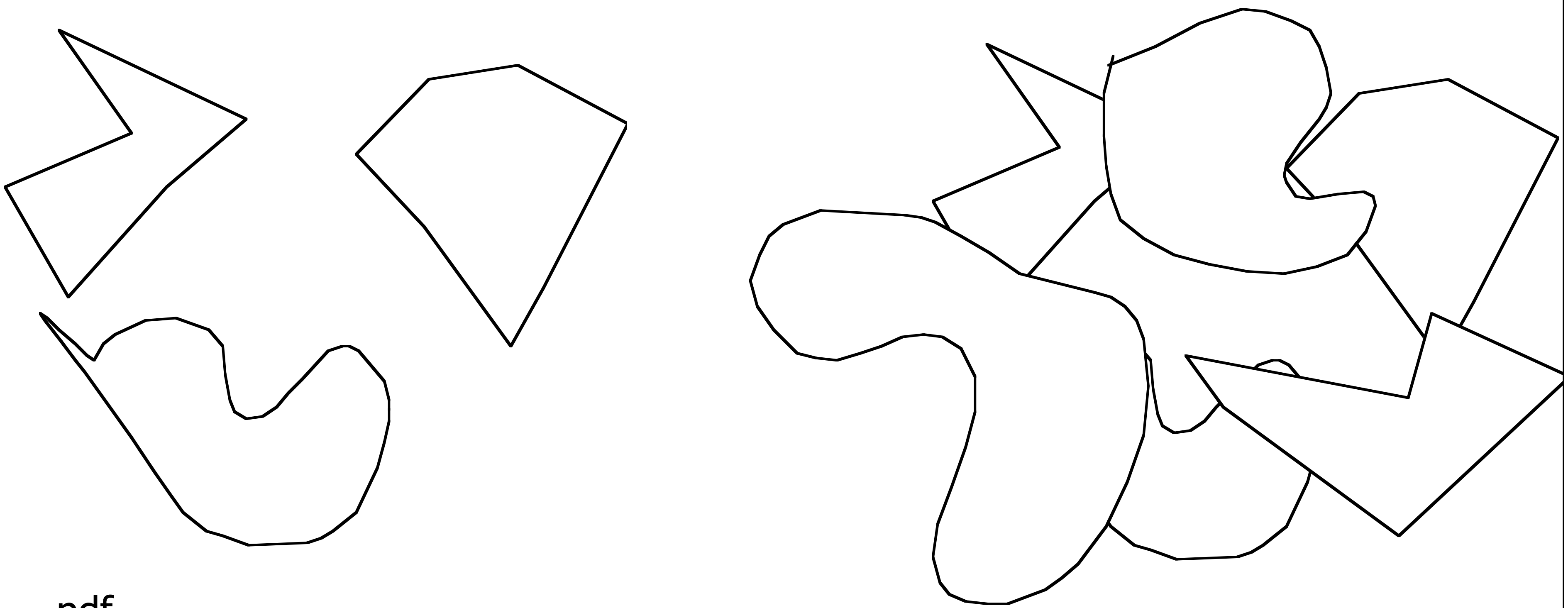
The Disappearing Money Multiplier

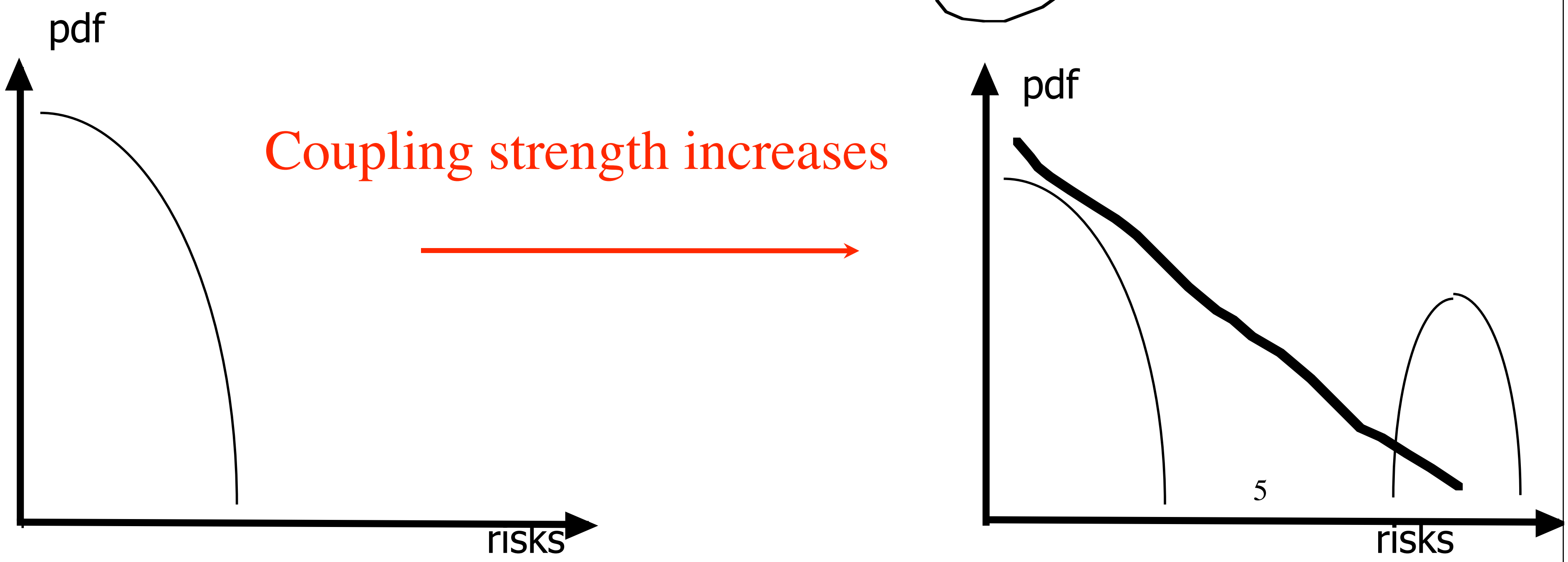


Econ prof Bill Seyfried of Rollins College:
The M1 money multiplier just slipped below 1. So each $1 increase in reserves (monetary base) results in the money supply increasing by $0.95 (OK, so banks have substantially increased their holding of excess reserves while the M1 money supply hasn't changed by much).

Separation of financial and credit risks

Securitization leads to larger inter-connectivity





THE GREAT MODERATION

This figure shows the rolling 10-year average real GDP growth rate along with one-standard deviation bands. These standard deviation bands provide a sense of how much variation or volatility there has been around the 10-year average real GDP growth rate. The figure shows a marked decline in the real GDP volatility beginning around 1983.

Beyond power laws: six examples of “kings”

Outliers and kings in the distribution of financial drawdowns.

Paris as the king in the Zipf distribution of French city sizes.

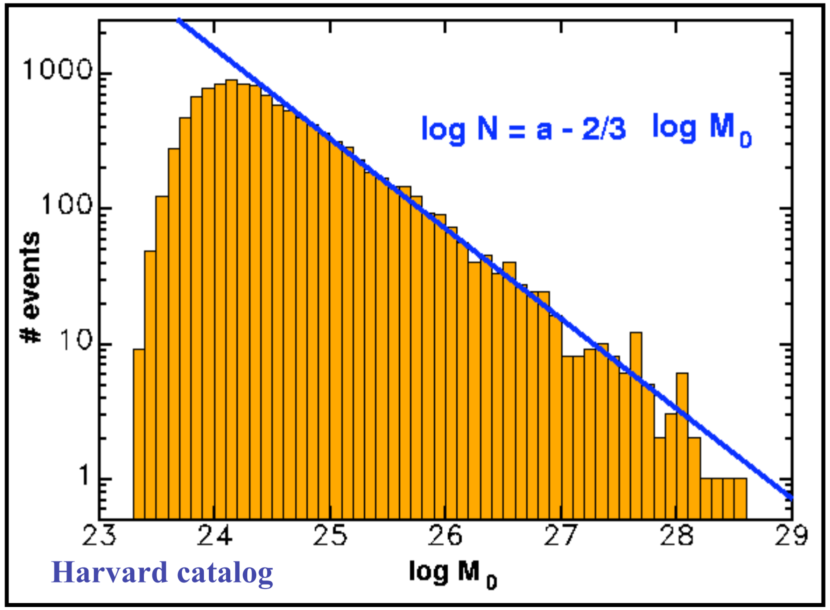
Material failure and rupture processes.

Extreme king events in the pdf of turbulent velocity fluctuations.

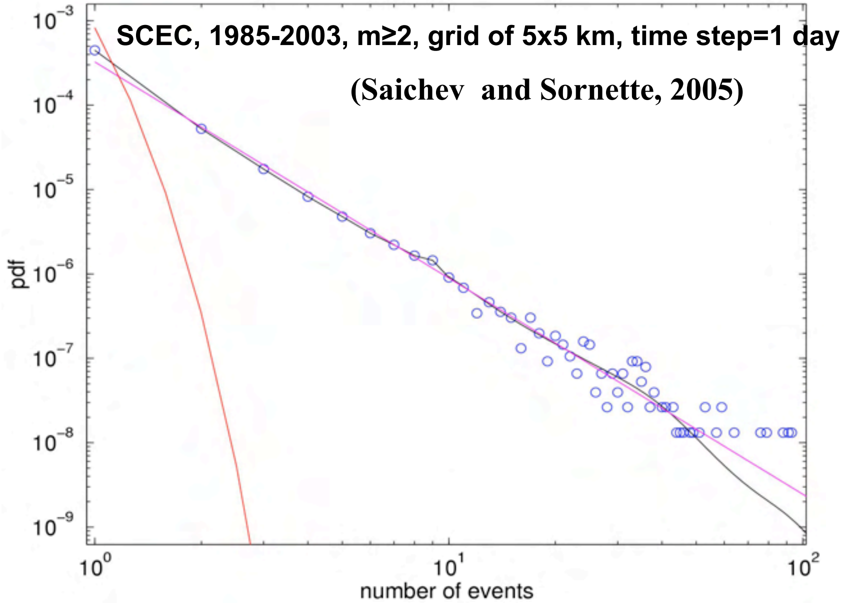
Epileptic seizures

Gutenberg-Richter law and characteristic earthquakes.

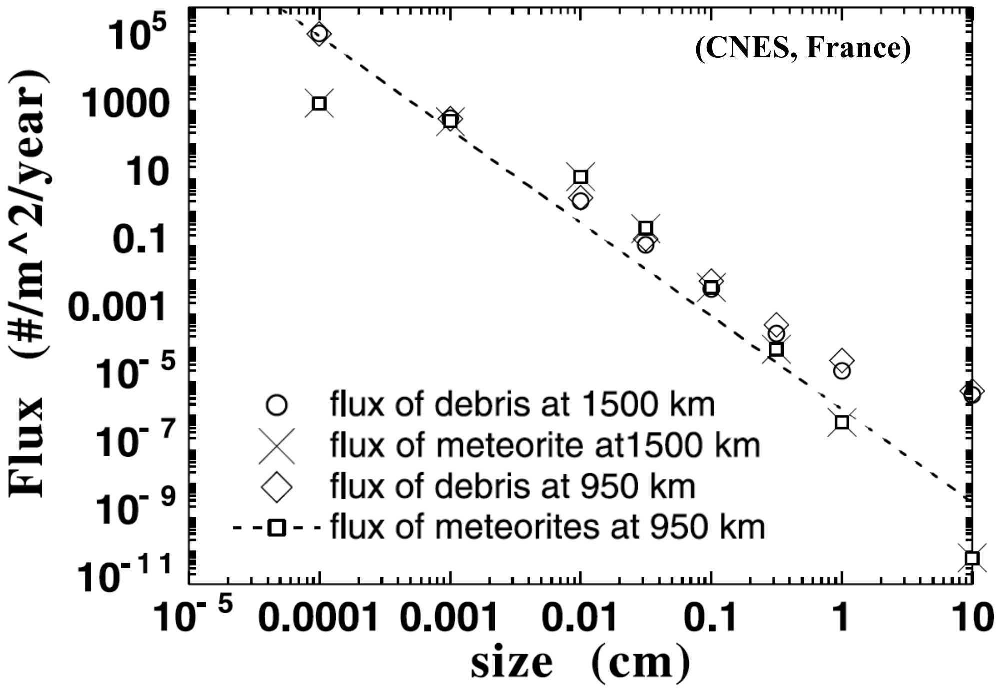
Heavy tails in pdf of earthquakes



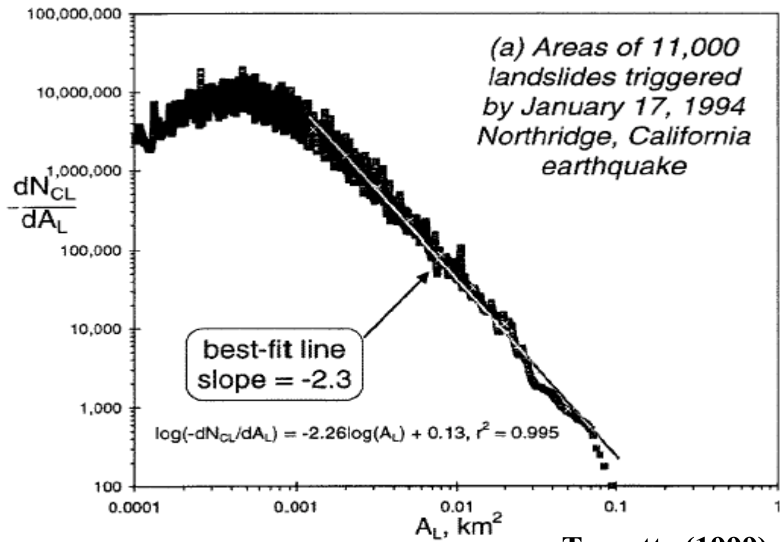
Heavy tails in pdf of seismic rates



Heavy tails in ruptures



Heavy tails in pdf of rock falls, Landslides, mountain collapses



Turcotte (1999)

Heavy tails in pdf of forest fires

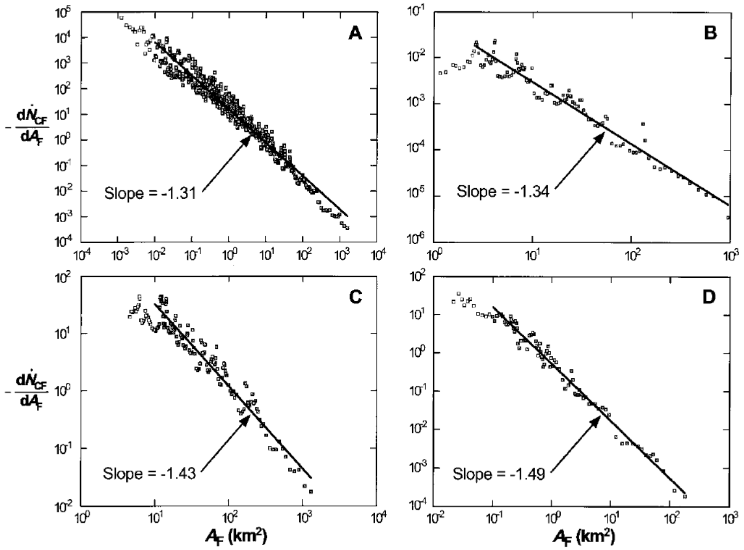
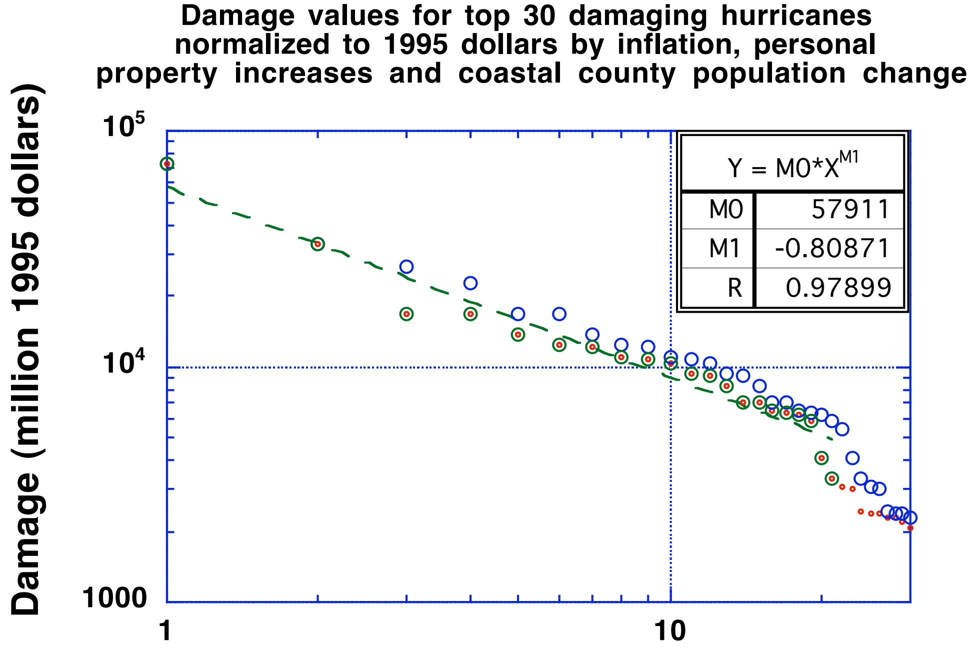


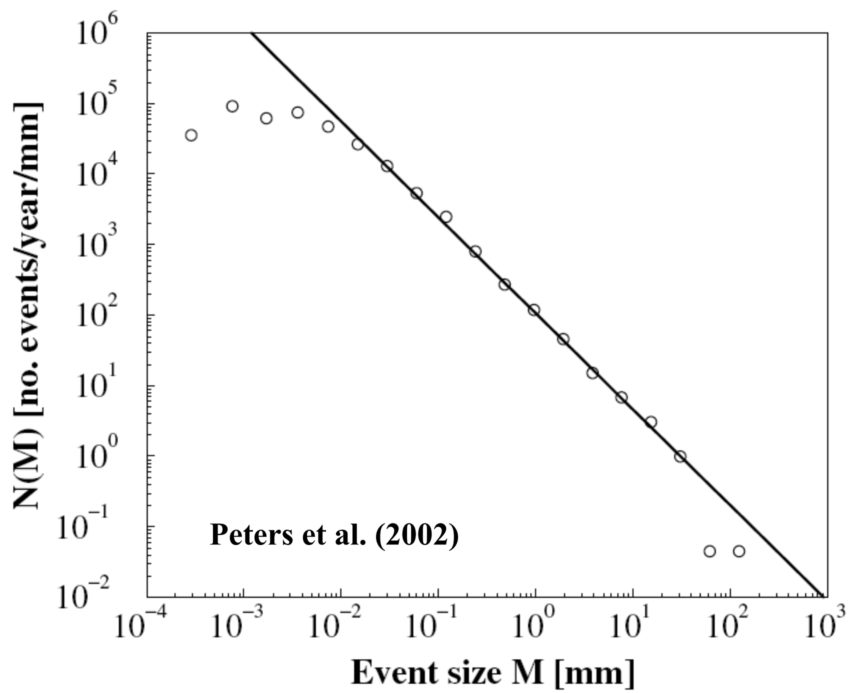
Fig. 2. Noncumulative frequency-area distributions for actual forest fires and wildfires in the United States and Australia: (**A**) 4284 fires on U.S. Fish and Wildlife Service lands (1986–1995) (*9*), (**B**) 120 fires in the western United States (1150–1960) (*10*), (**C**) 164 fires in Alaskan boreal forests (1990–1991) (*11*), and (**D**) 298 fires in the ACT (1926–1991) (*12*). For each data set, the noncumulative number of fires per year ($-d\dot{N}_{CF}/dA_F$) with area (A_F) is given as a function of A_F (*13*). In each case, a reasonably good correlation over many decades of A_F is obtained by using the power-law relation (Eq. 1) with α = 1.31 to 1.49; $-\alpha$ is the slope of the best-fit line in log-log space and is shown for each data set.

Malamud et al., Science 281 (1998)

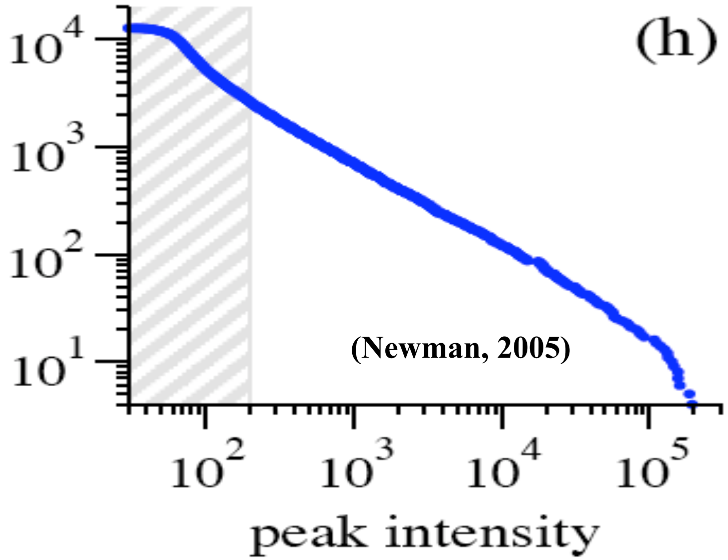
Heavy tails in cdf of Hurricane losses

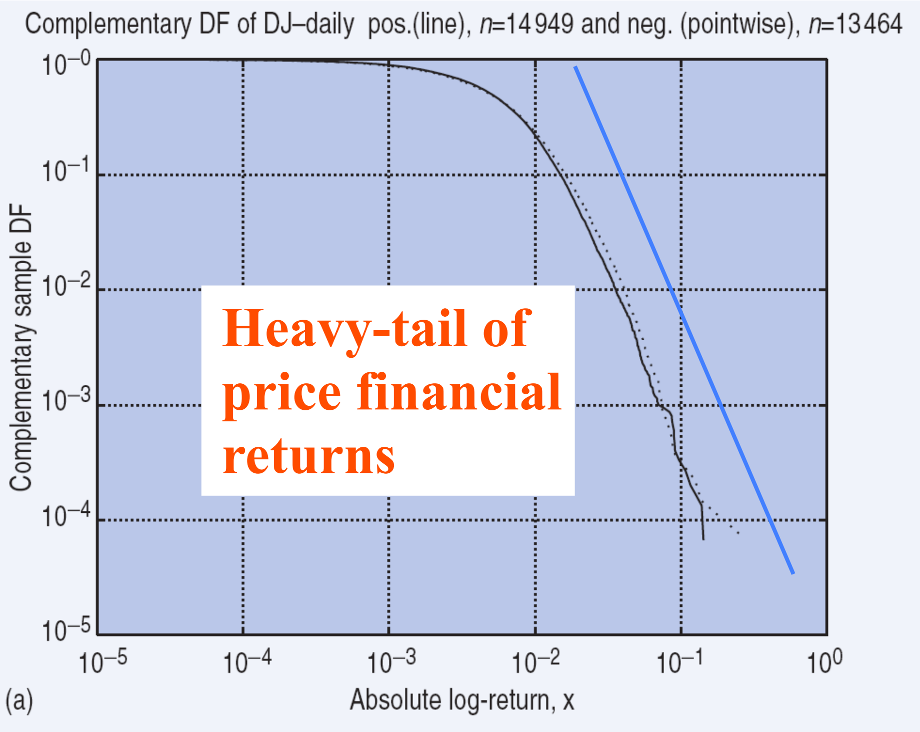


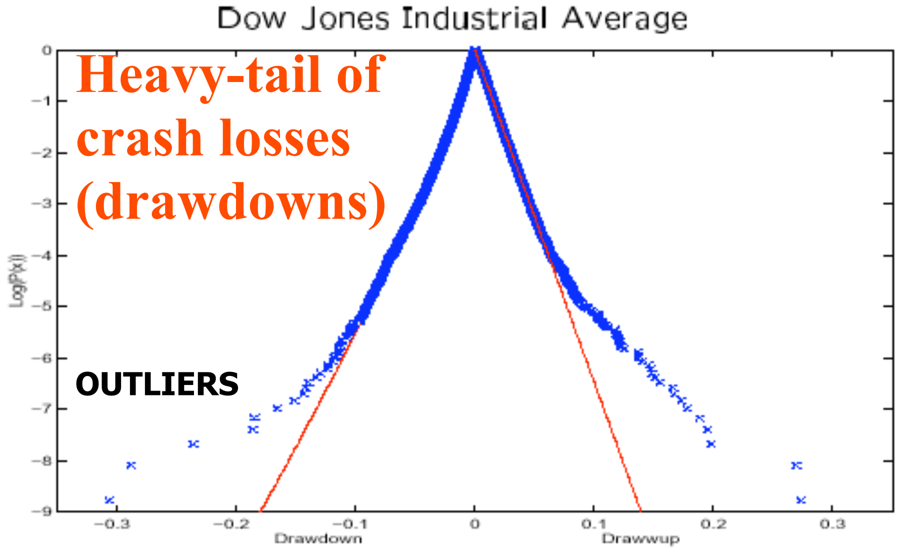
Heavy tails in pdf of rain events

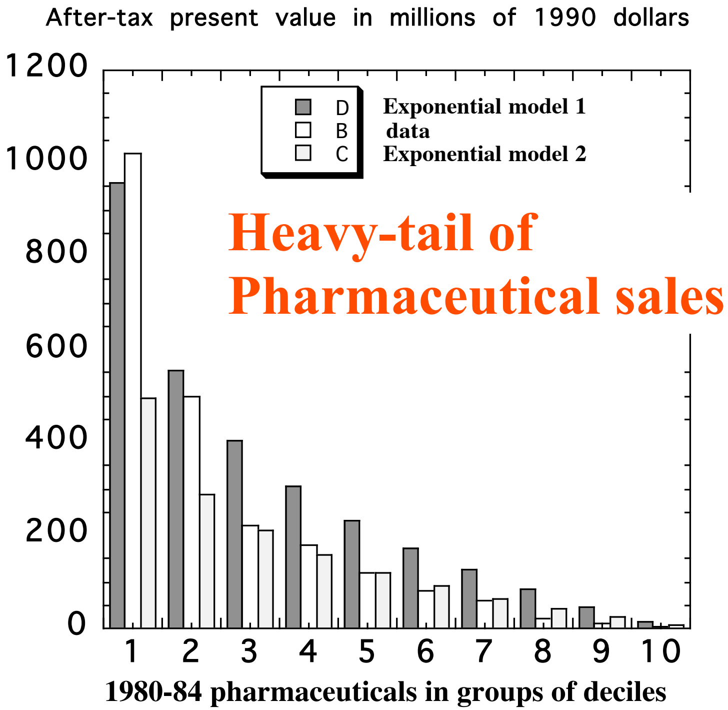


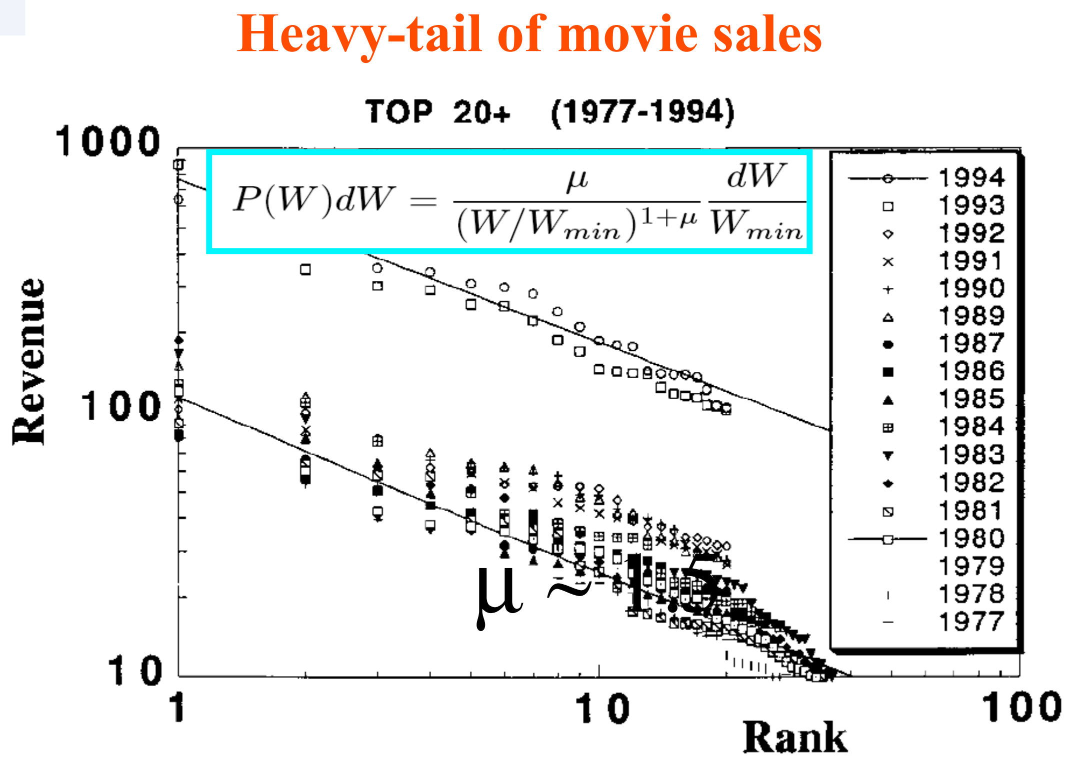
Heavy tails in cdf of Solar flares



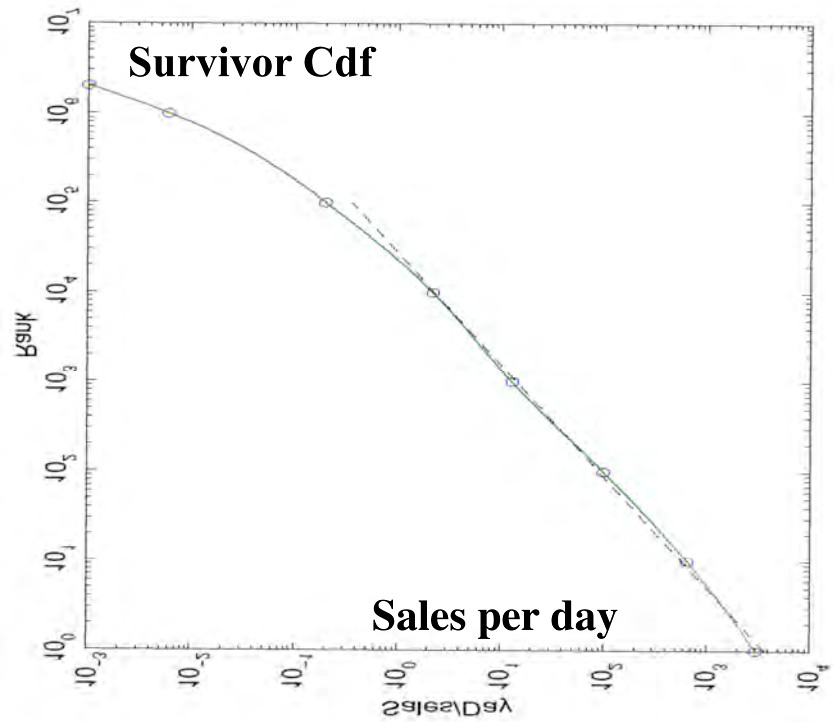

Complementary DF of DJ–daily pos.(line), n=14 949 and neg. (pointwise), n=13 464
Complementary sample DF
Absolute log-return, x
(a)
Heavy-tail of price financial returns


Dow Jones Industrial Average
Heavy-tail of crash losses (drawdowns)
OUTLIERS
LogP(x|)
Drawdown
Drawwup

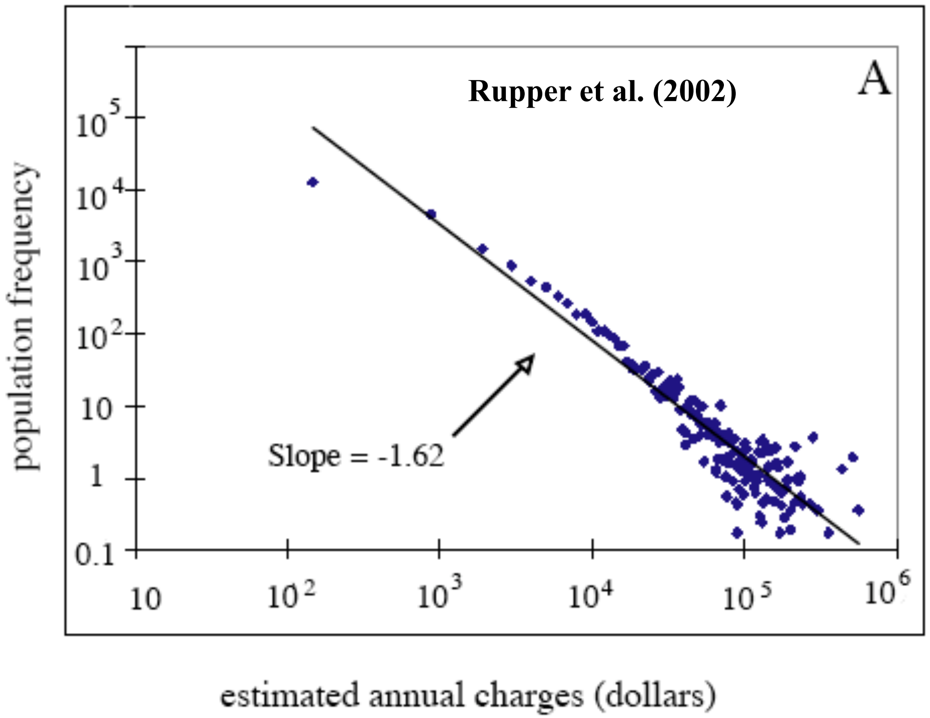

After-tax present value in millions of 1990 dollars
D Exponential model 1
B data
C Exponential model 2
Heavy-tail of Pharmaceutical sales
1980-84 pharmaceuticals in groups of deciles


Heavy-tail of movie sales
TOP 20+ (1977-1994)
$P(W)dW = \frac{\mu}{(W/W_{min})^{1+\mu}} \frac{dW}{W_{min}}$
Revenue
Rank
1994 1993 1992 1991 1990 1989 1987 1986 1985 1984 1983 1982 1981 1980 1979 1978 1977

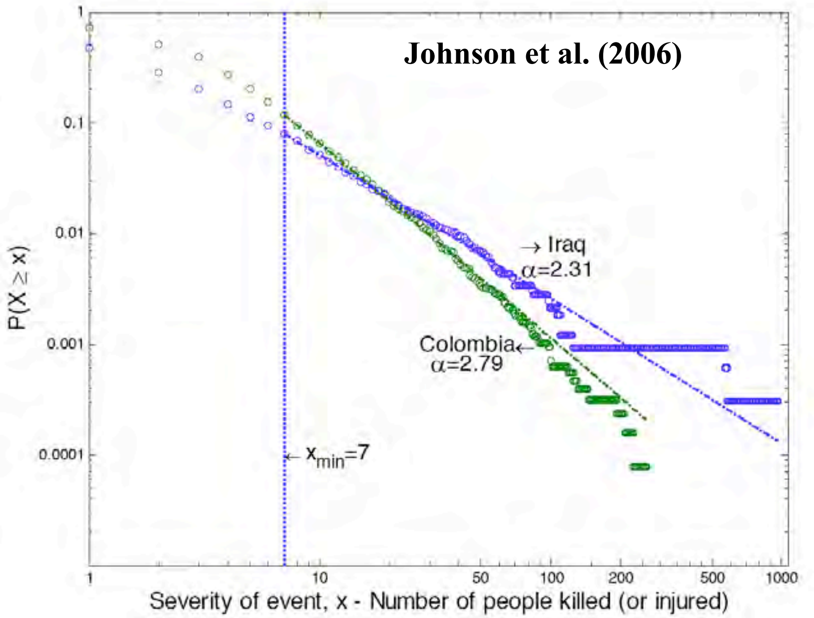
Heavy-tail of cdf of book sales

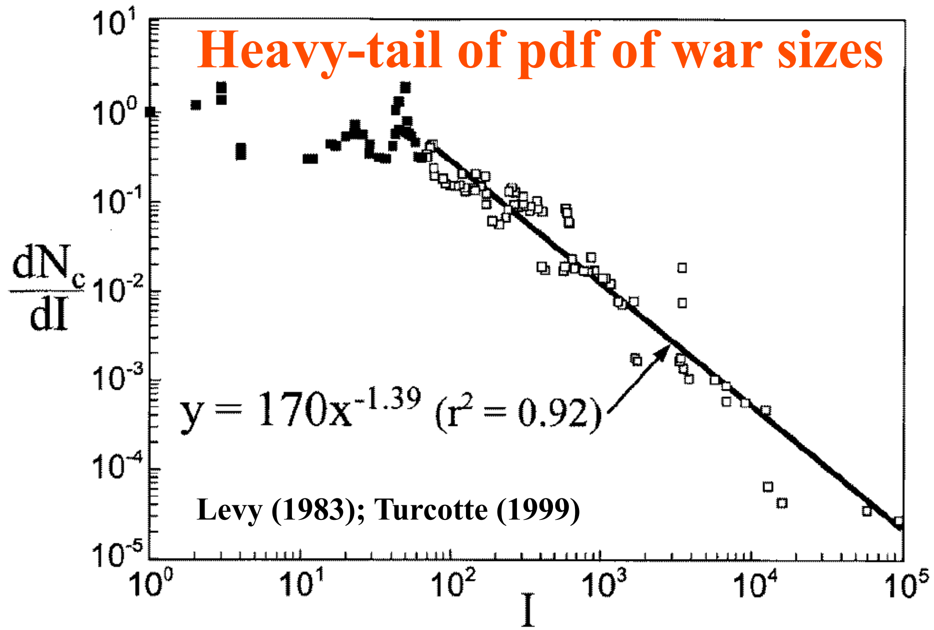


Heavy-tail of pdf of health care costs

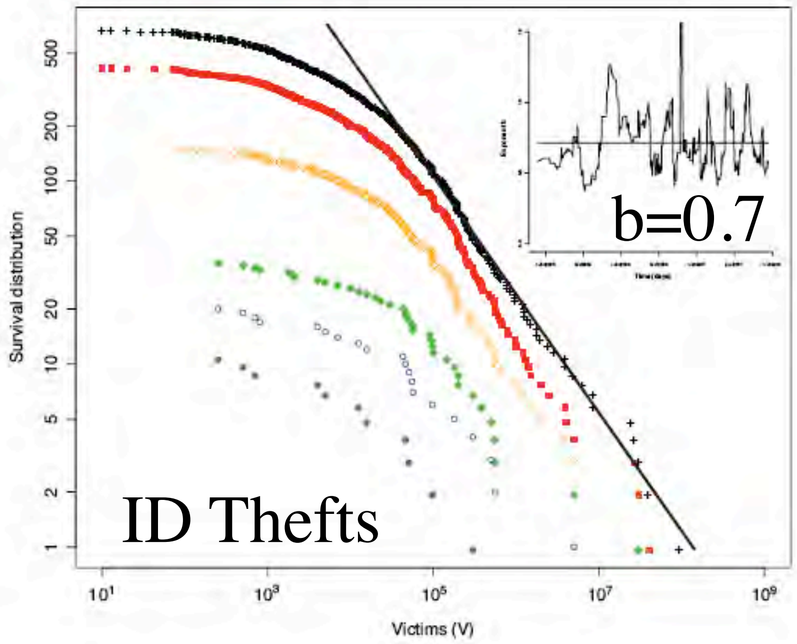


Heavy-tail of cdf of terrorist intensity

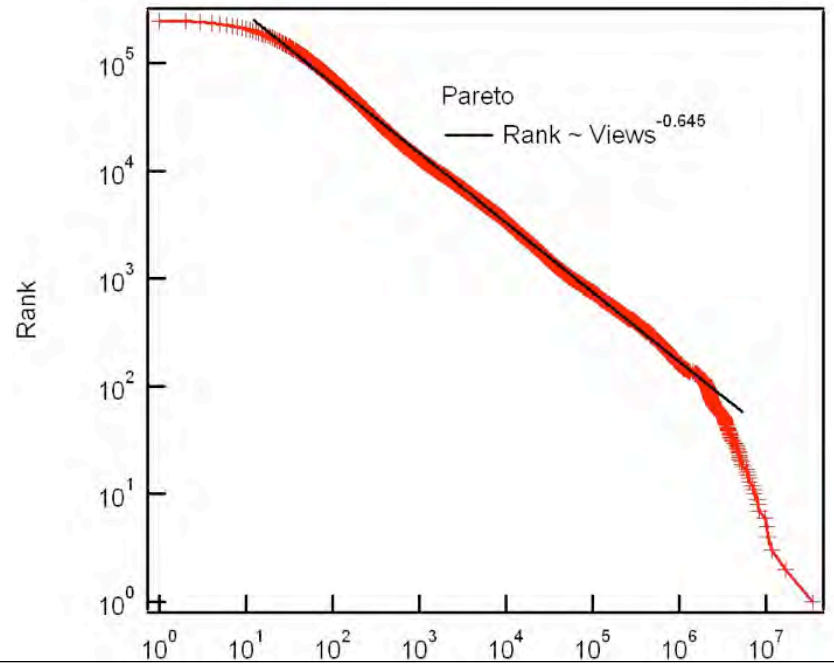




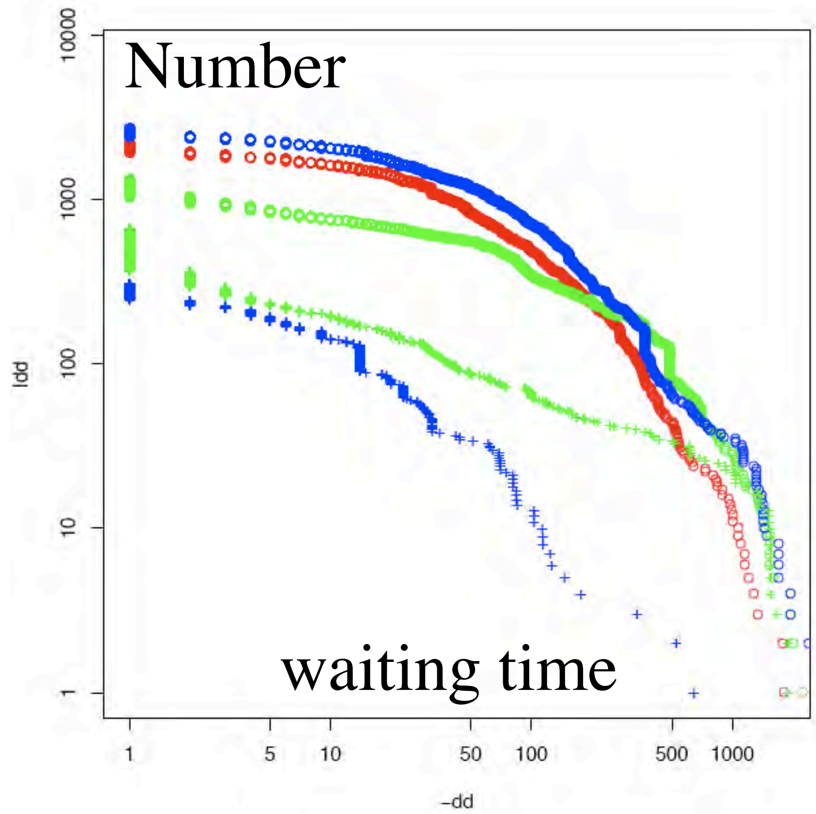
Heavy-tail of cdf of cyber risks



Heavy-tail of YouTube view counts



Software vulnerabilities



Firm sizes (Zipf's law)

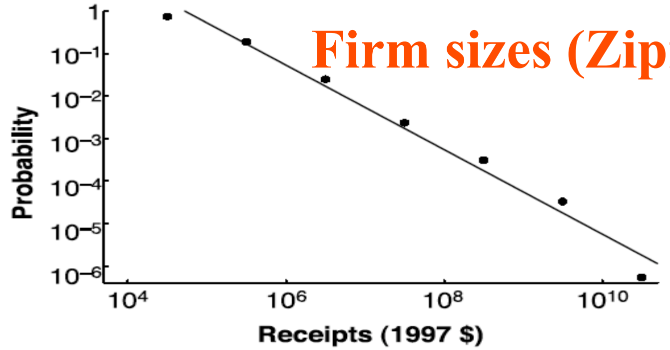
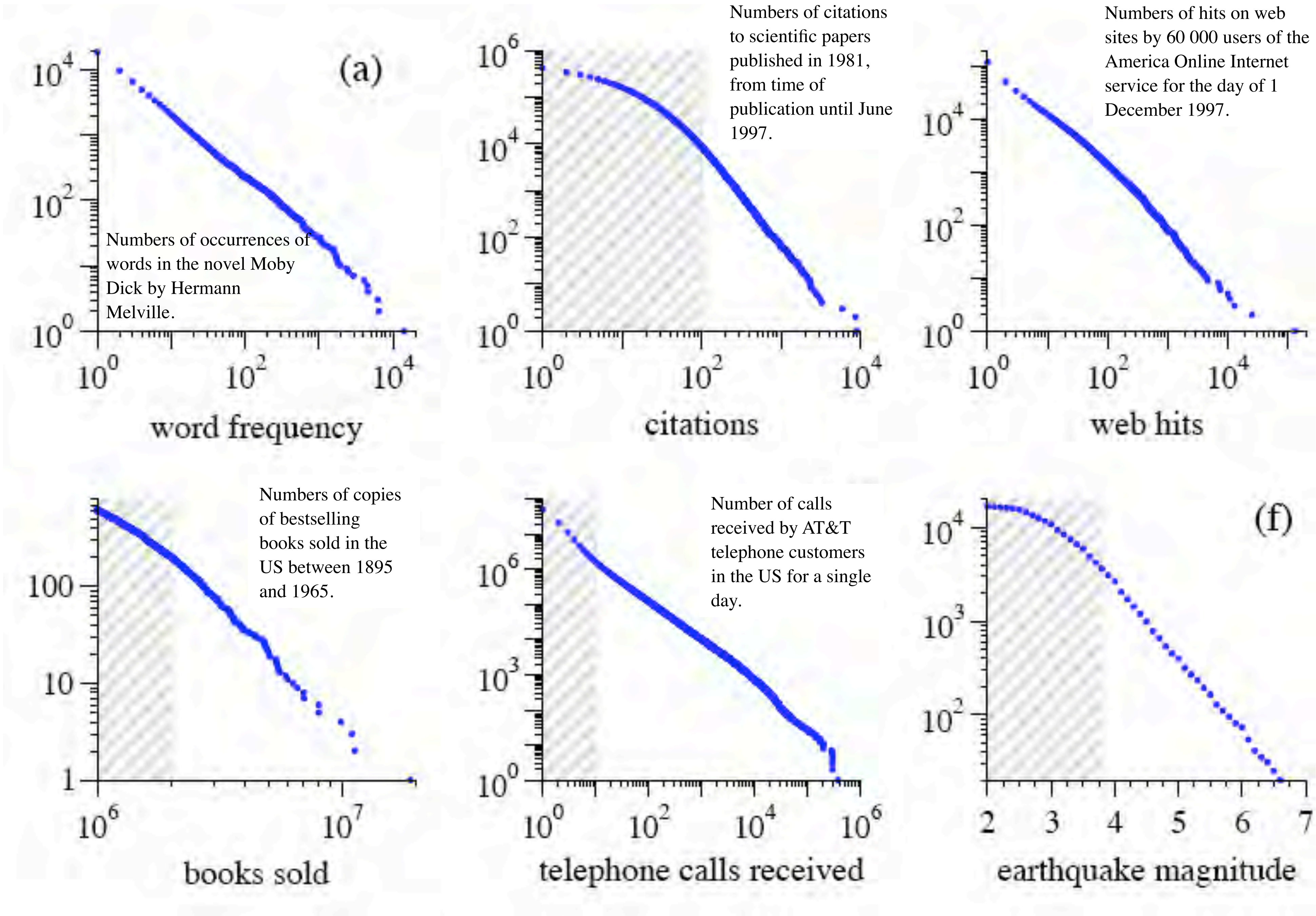


Fig. 2. Tail cumulative distribution function of U.S. firm sizes, by receipts in dollars. Data are for 1997 from the U.S. Census Bureau, tabulated in bins whose width increases in powers of 10. The solid line is the OLS regression line through the data and has slope of 0.994 (SE = 0.064; adjusted R^2 = 0.976).

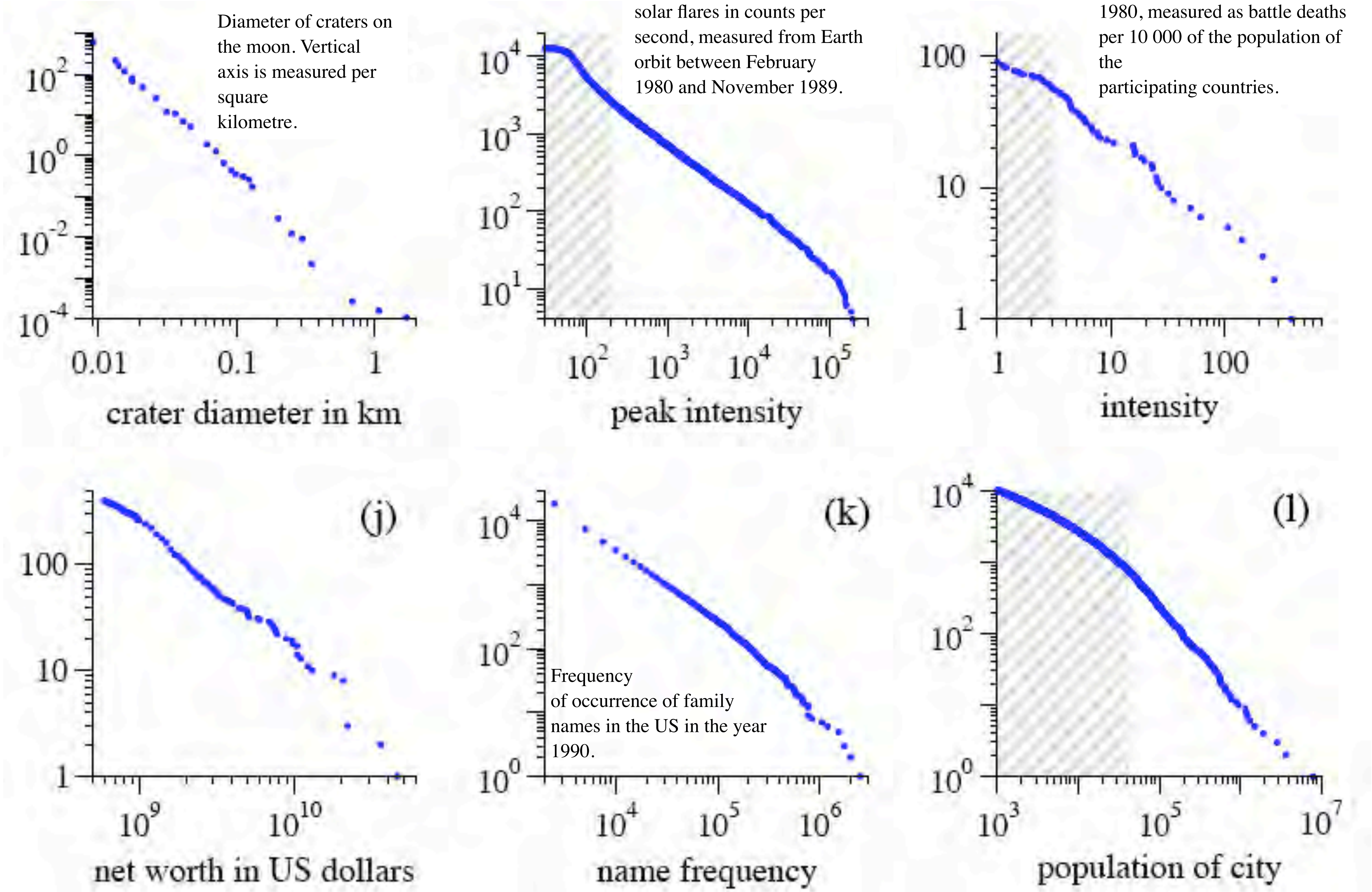


M. E. J. Newman, Power laws, Pareto distributions and Zipf’s law (2005)

Diameter of craters on the moon. Vertical axis is measured per square kilometre.

Peak gamma-ray intensity of solar flares in counts per second, measured from Earth orbit between February 1980 and November 1989.

Intensity of wars from 1816 to 1980, measured as battle deaths per 10 000 of the population of the participating countries.



Frequency of occurrence of family names in the US in the year 1990.

M. E. J. Newman, Power laws, Pareto distributions and Zipf’s law (2005)

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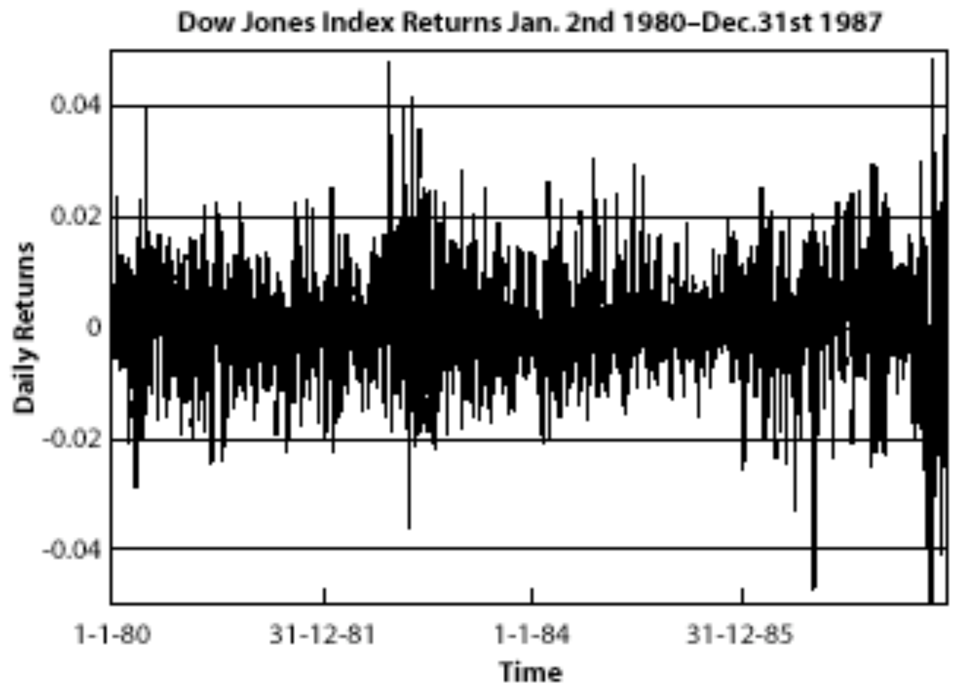
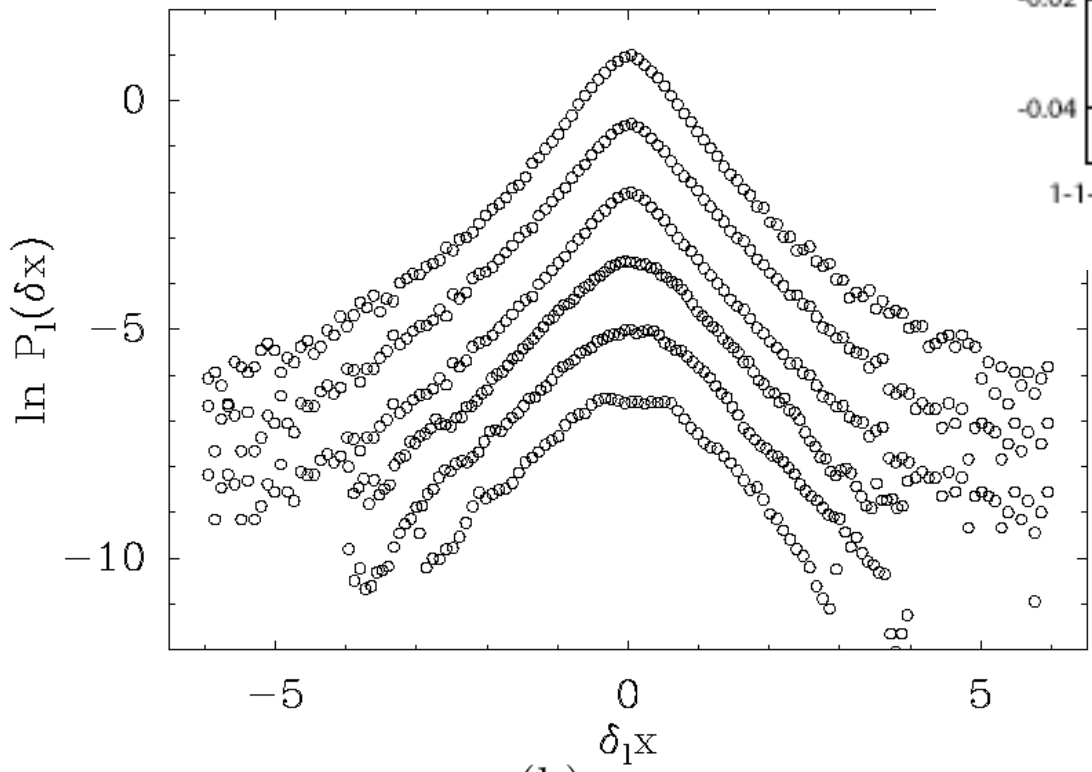
Gutenberg-Richter law and characteristic earthquakes.

THE CONCEPT OF "Kings"

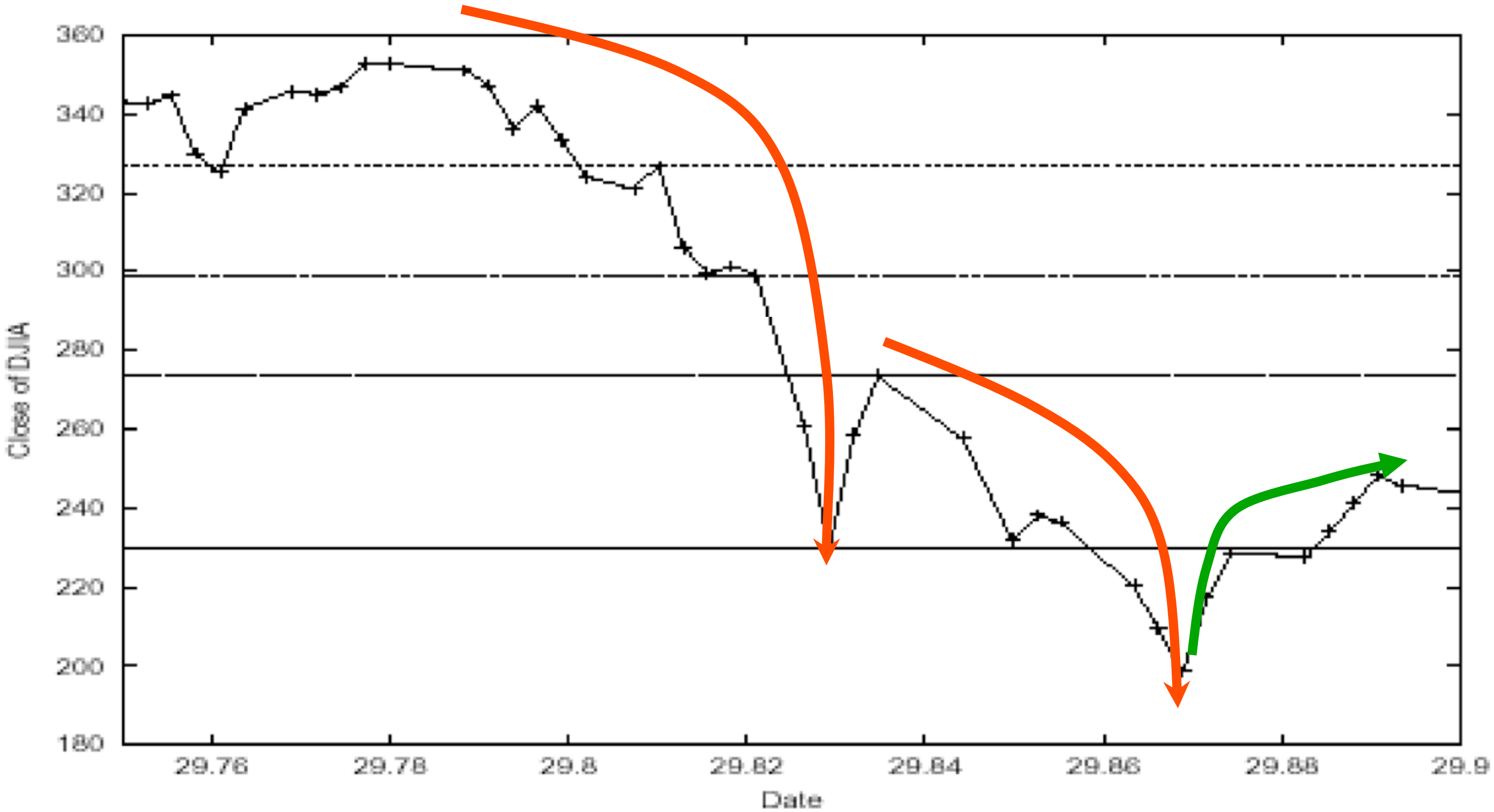
Traditional emphasis on Daily returns do not reveal any anomalous events



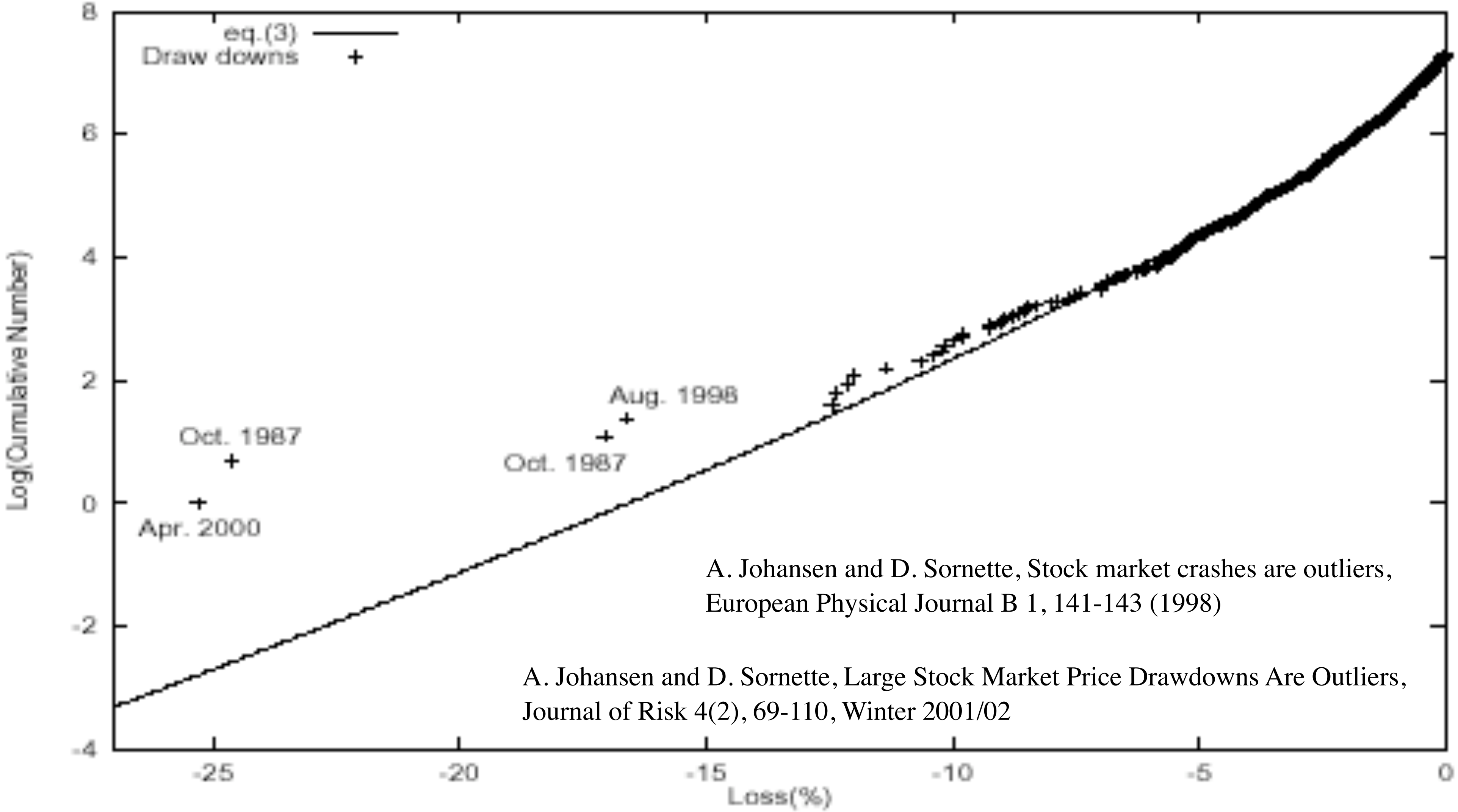


(b)

Better risk measure: drawdowns



Outlier or King effect



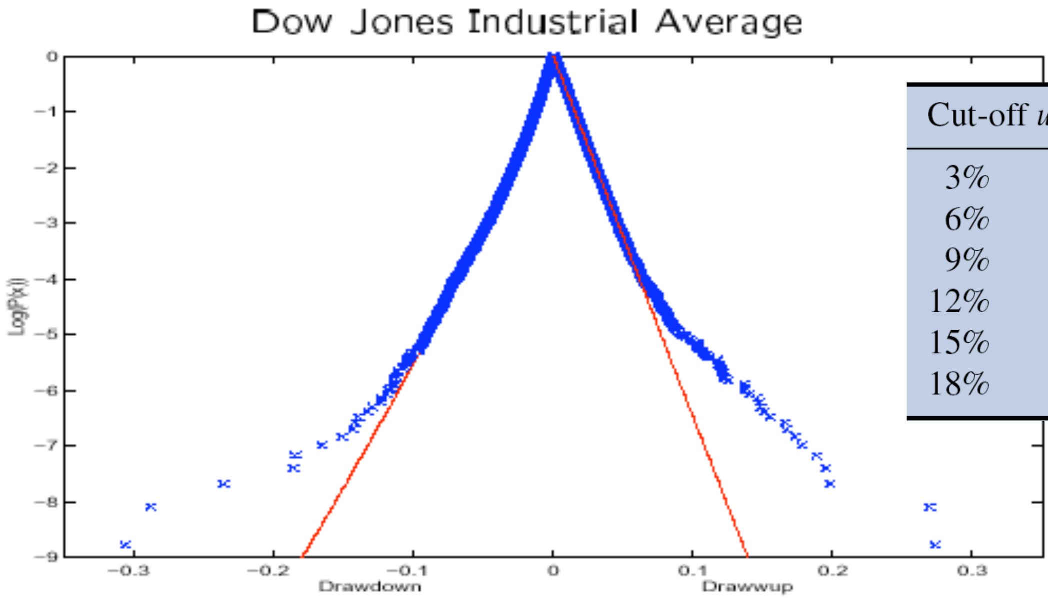
A. Johansen and D. Sornette, Stock market crashes are outliers, European Physical Journal B 1, 141-143 (1998)

A. Johansen and D. Sornette, Large Stock Market Price Drawdowns Are Outliers, Journal of Risk 4(2), 69-110, Winter 2001/02

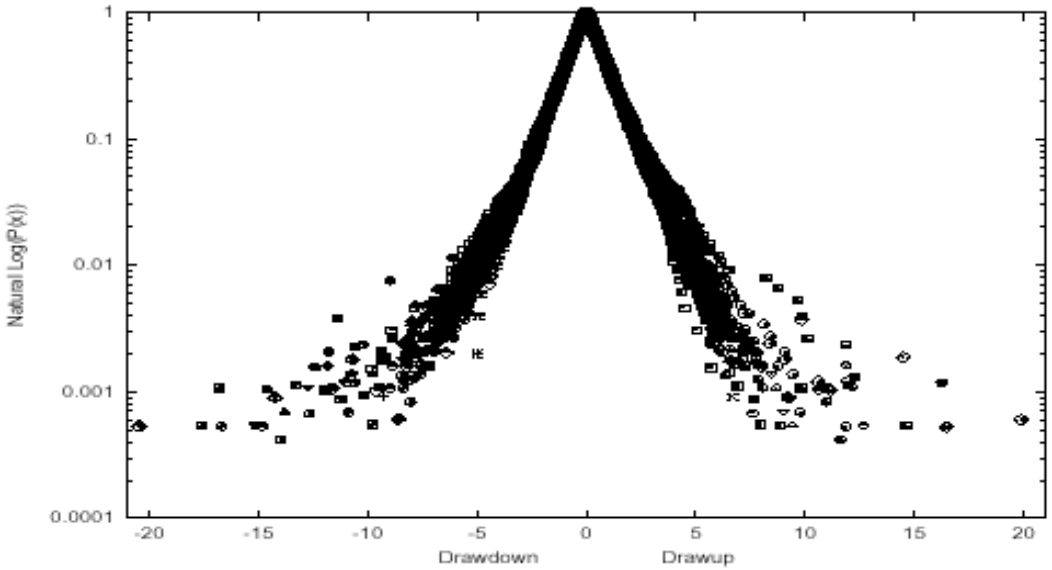
$$N(DD) = A \exp\left(-\left(|DD|/\chi\right)^z\right).$$

Outliers, Kings

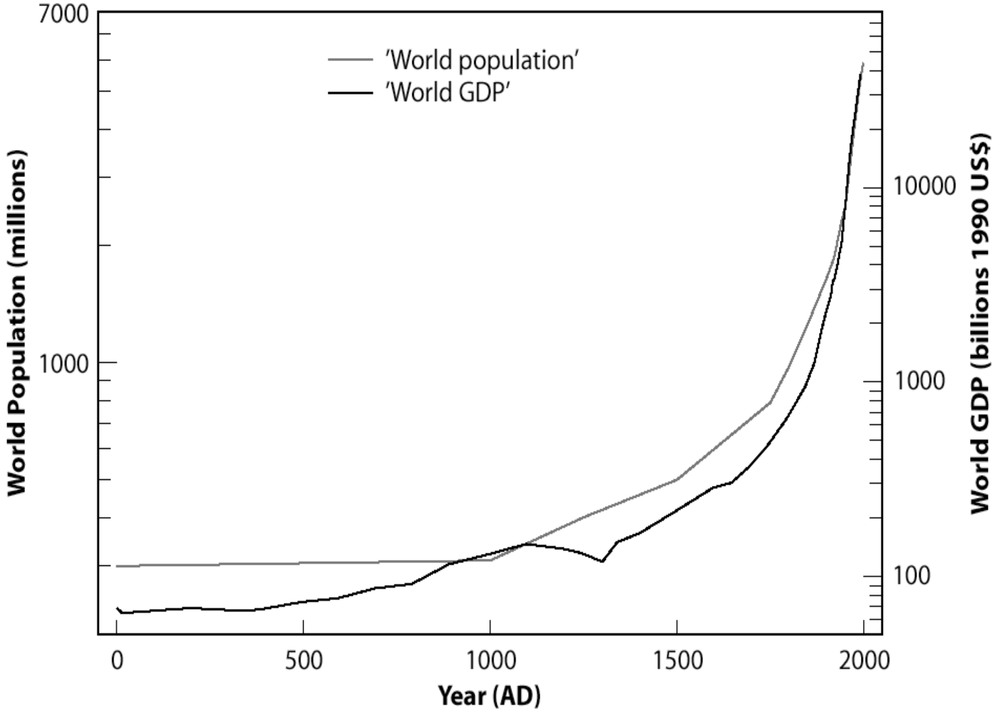
(require special mechanism and may be more predictable)



Cut-off u	Quantile	z	$\ln(L_0)$	$\ln(L_1)$	T	Proba
3%	87%	0.916, 0.940	4890.36	4891.16	1.6	20.5%
6%	97%	0.875, 0.915	4944.36	4947.06	5.4	2.0%
9%	99.0%	0.869, 0.918	4900.75	4903.66	5.8	1.6%
12%	99.7%	0.851, 0.904	4872.47	4877.46	10.0	0.16%
15%	99.7%	0.843, 0.898	4854.97	4860.77	11.6	0.07%
18%	99.9%	0.836, 0.890	4845.16	4851.94	13.6	0.02%



Positive feedbacks

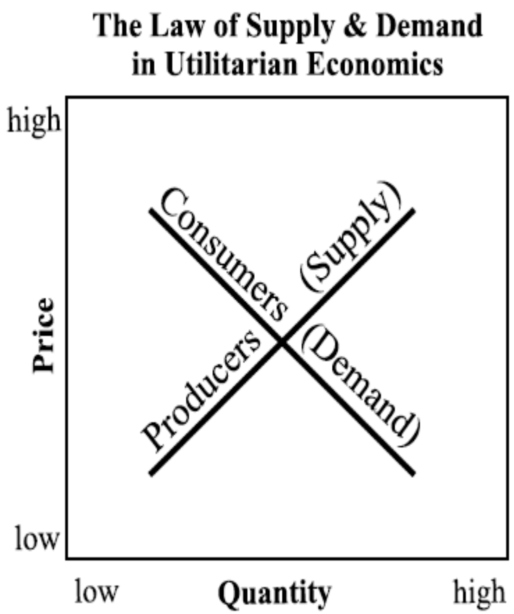


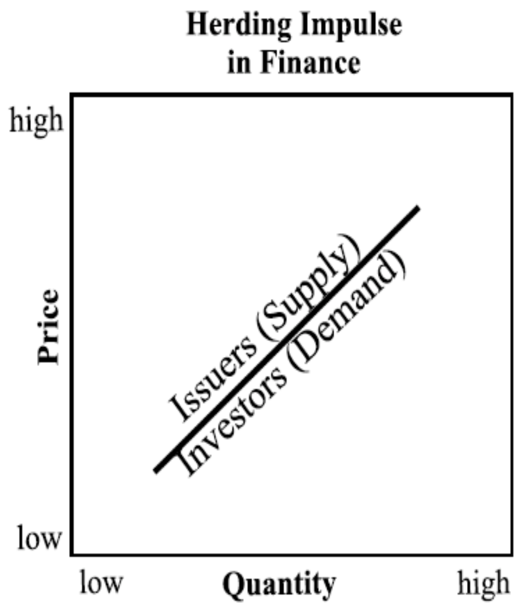
$$\frac{dp}{dt} = rp(t)[K - p(t)].$$

$$\frac{dp}{dt} = r[p(t)]^{1+\delta},$$

with $K \propto p^{\delta}$

$$p(t) \propto (t_c - t)^z, \text{ with } z = -\frac{1}{\delta}$$





Paris as a king

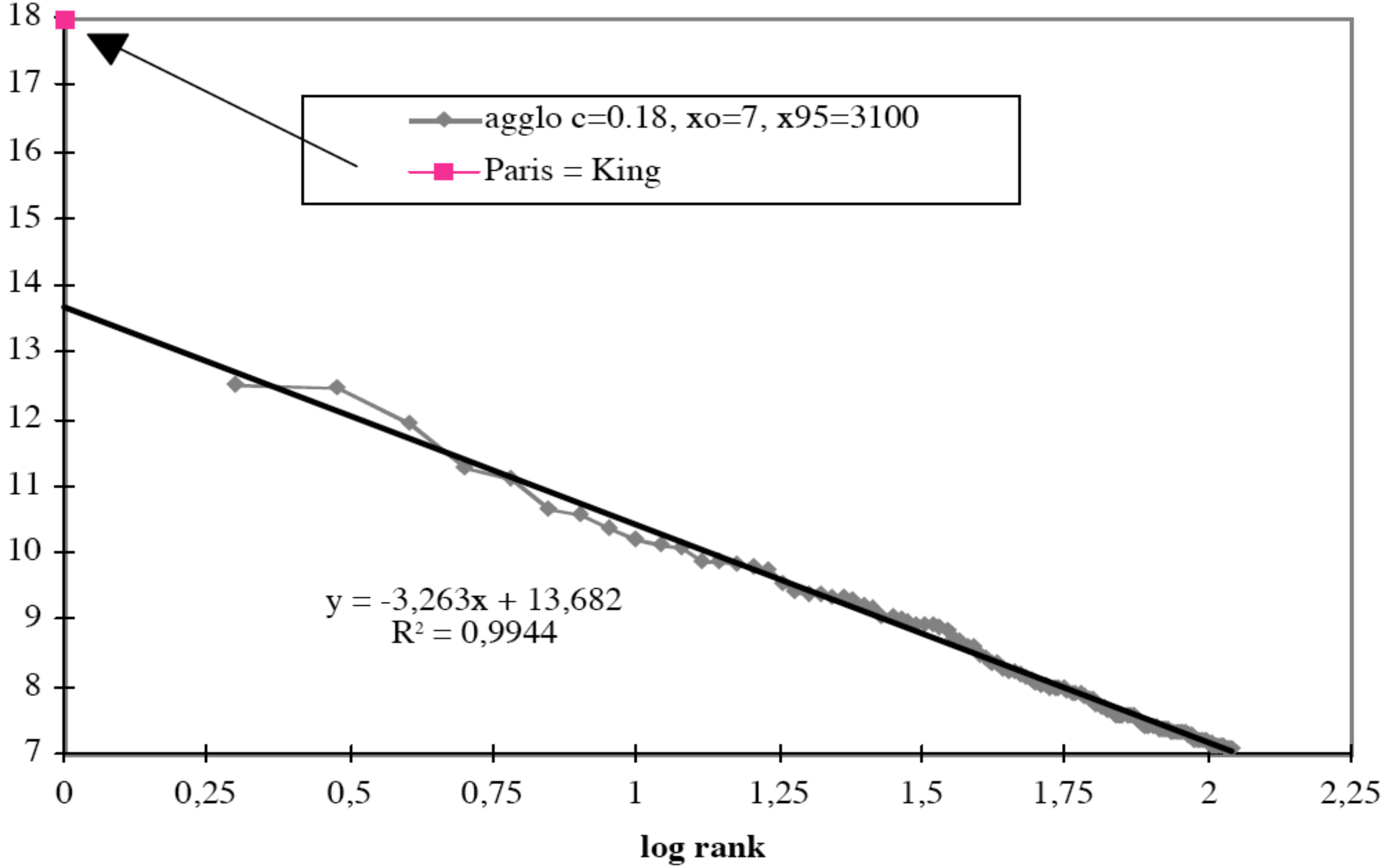


Fig. 7. French agglomerations: stretched exponential and "King effect".

Jean Laherrere and Didier Sornette, Stretched exponential distributions in Nature and Economy: ``Fat tails'' with characteristic scales, European Physical Journal B 2, 525-539 (1998)

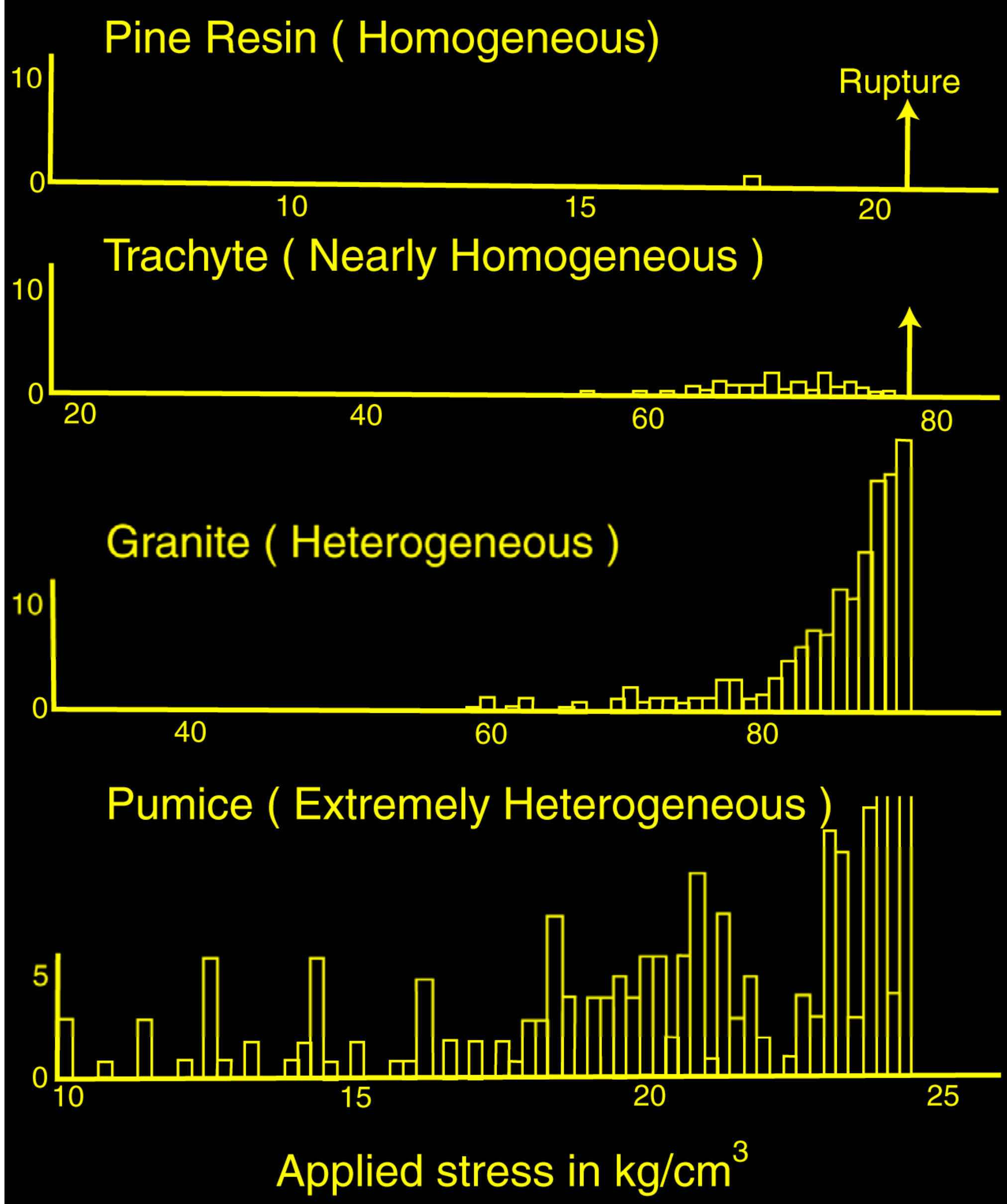
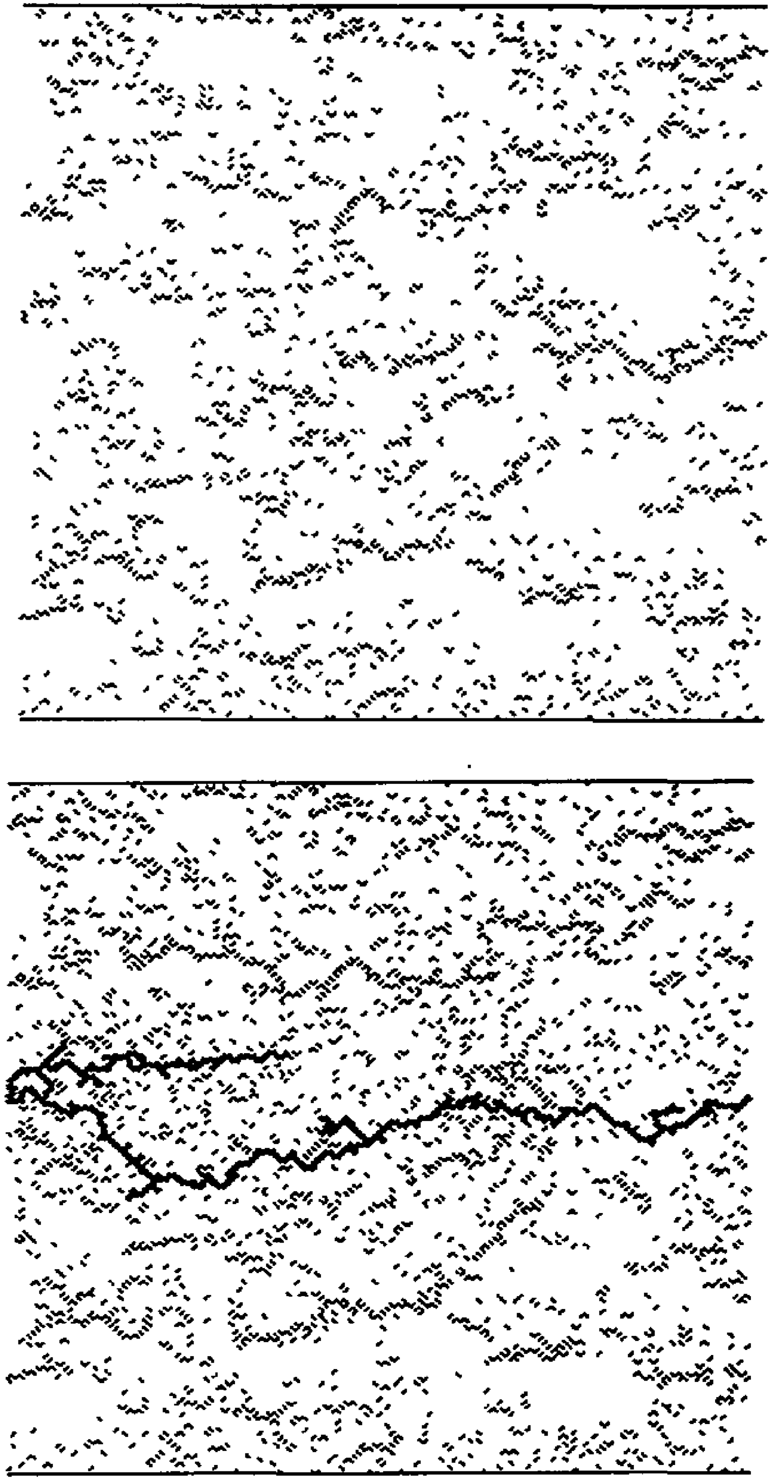
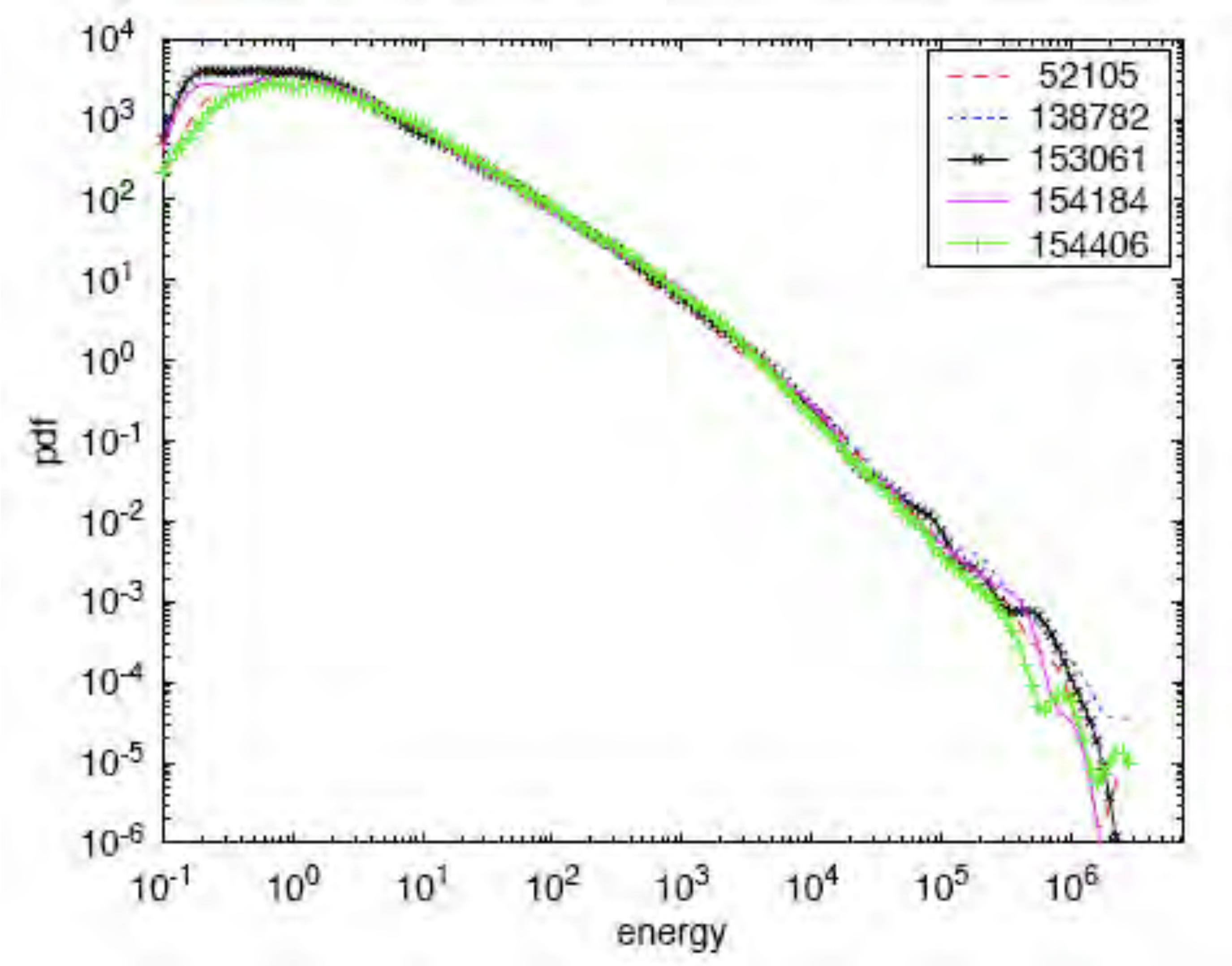


Fig. 4. Frequency of elastic shocks under increasing stresses in materials with different heterogeneity. From Mogi [1962]





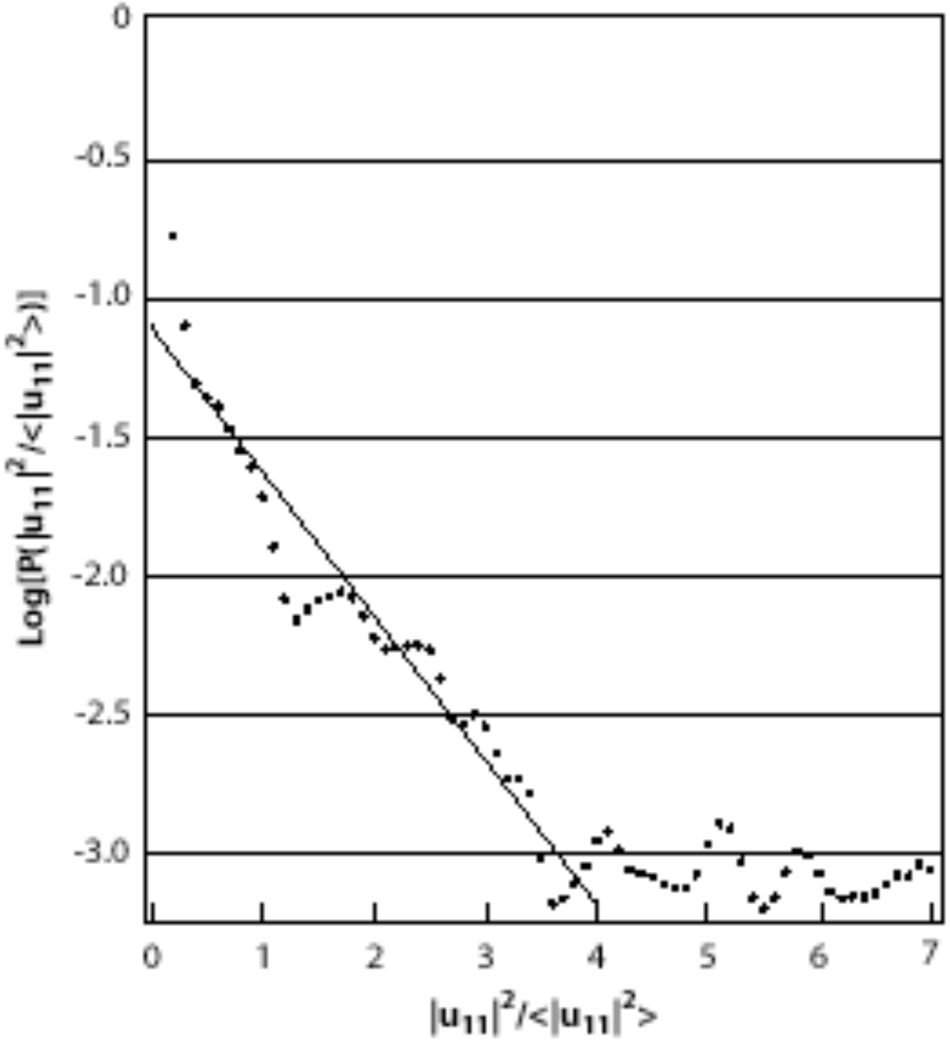
• • •

Energy distribution for the [+-62] specimen #4 at different times, for 5 time windows with 3400 events each. The average time (in seconds) of events in each window is given in the caption.

H. Nechad, A. Helmstetter, R. El Guerjouma and D. Sornette, Andrade and Critical Time-to-Failure Laws in Fiber-Matrix Composites: Experiments and Model, Journal of Mechanics and Physics of Solids (JMPS) 53, 1099-1127 (2005)

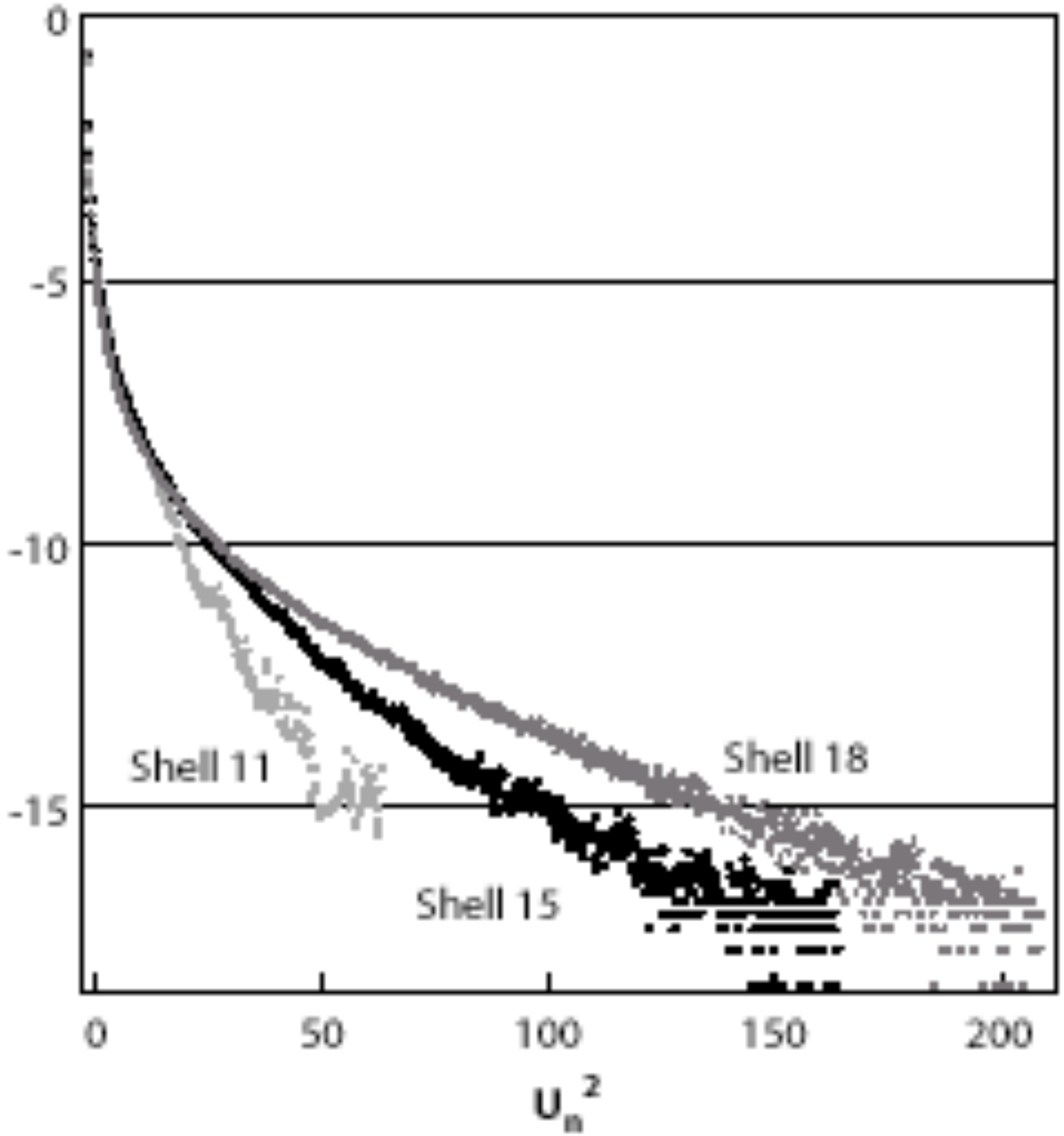
Mathematical Geophysics Conference Extreme Earth Events

Villefranche-sur-Mer, 18-23 June 2000



L'vov, V.S., Pomyalov, A. and Procaccia, I. (2001) Outliers, Extreme Events and Multiscaling, Physical Review E 6305 (5), 6118, U158-U166.

FIG. 3.2. Apparent probability distribution function of the square of the fluid velocity, normalized to its time average, in the eleventh shell of the toy model of hydrodynamic turbulence discussed in the text. The vertical axis is in logarithmic scale such that the straight line, which helps the eye, qualifies as an apparent exponential distribution. Note the appearance of extremely sparse and large bursts of velocities at the extreme right above the extrapolation of the straight line. Reproduced from [252].



Pdf of the square of the Velocity as in the previous figure but for a much longer time series, so that the tail of the distributions for large Fluctuations is much better constrained. The hypothesis that there are no outliers is tested here by collapsing the distributions for the three shown layers. While this is a success for small fluctuations, the tails of the distributions for large events are very different, indicating that extreme fluctuations belong to a different class of their own and hence are outliers.

L'vov, V.S., Pomyalov, A. and Procaccia, I. (2001) Outliers, Extreme Events and Multiscaling, Physical Review E 6305 (5), 6118, U158-U166.

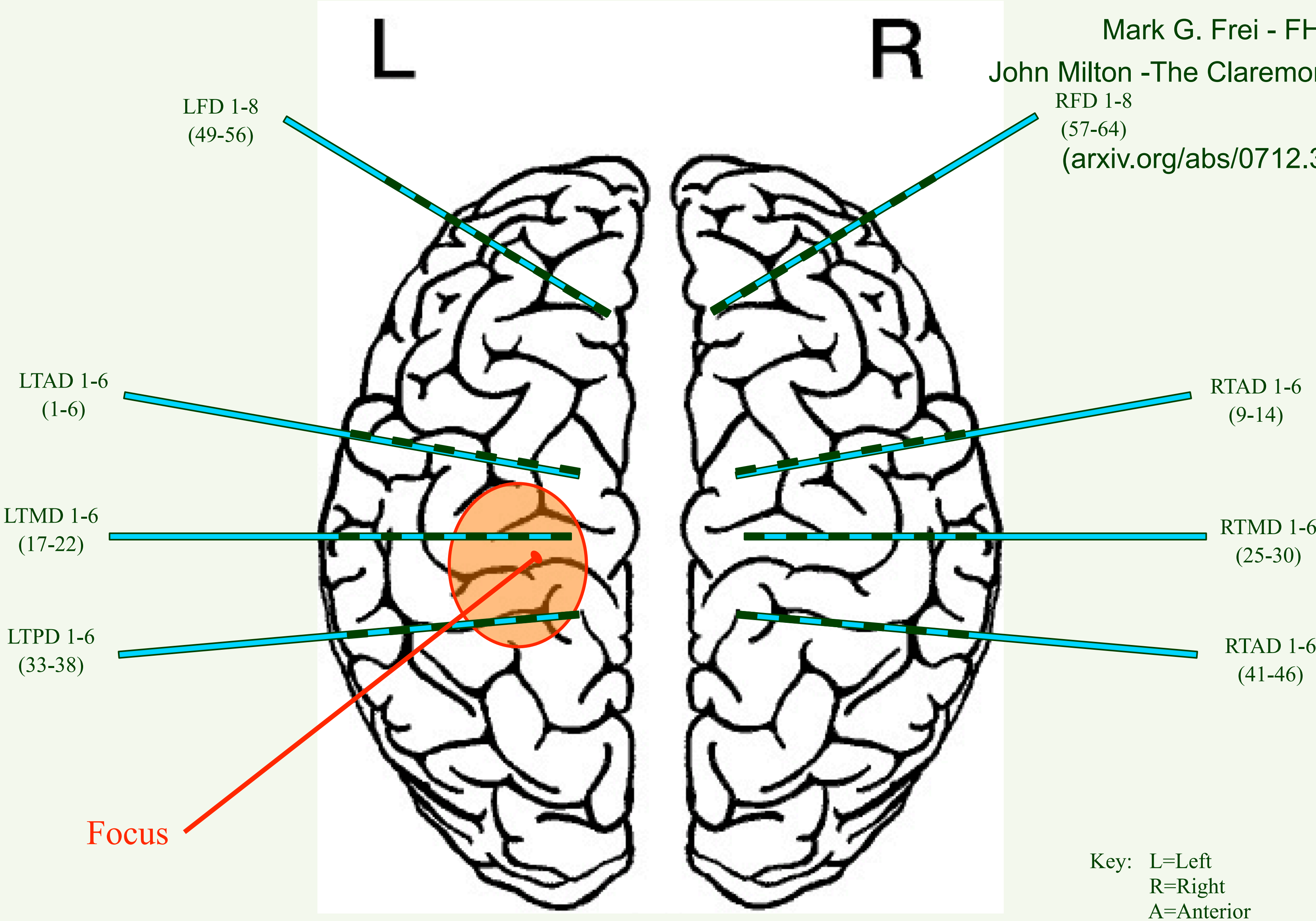
Epileptic Seizures – Quakes of the Brain?

with Ivan Osorio – KUMC & FHS

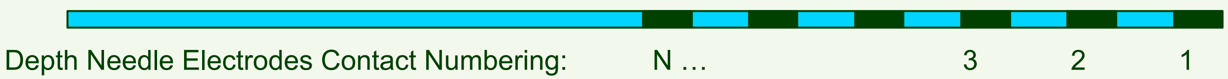
Mark G. Frei - FHS

John Milton -The Claremont Colleges

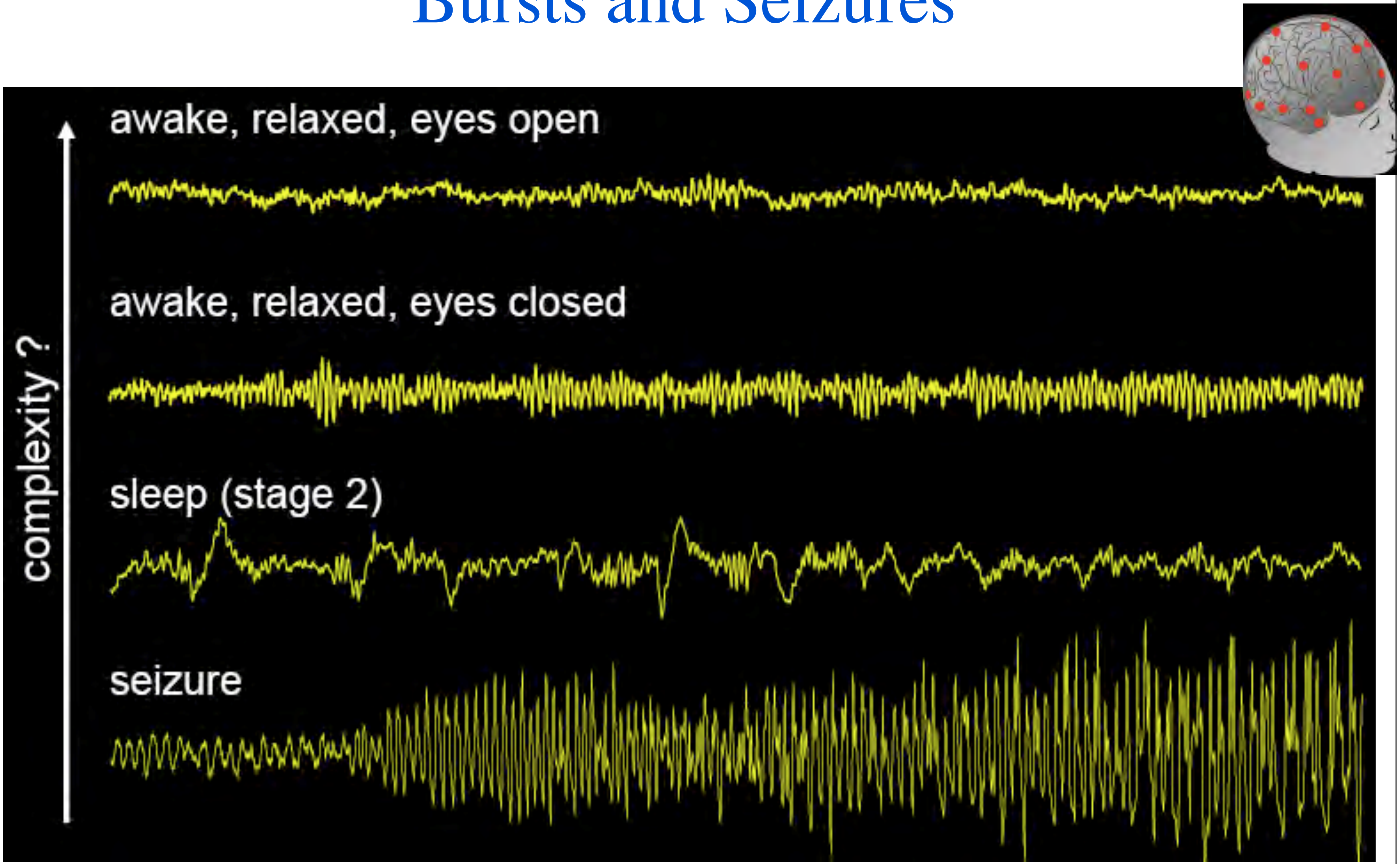
(arxiv.org/abs/0712.3929)



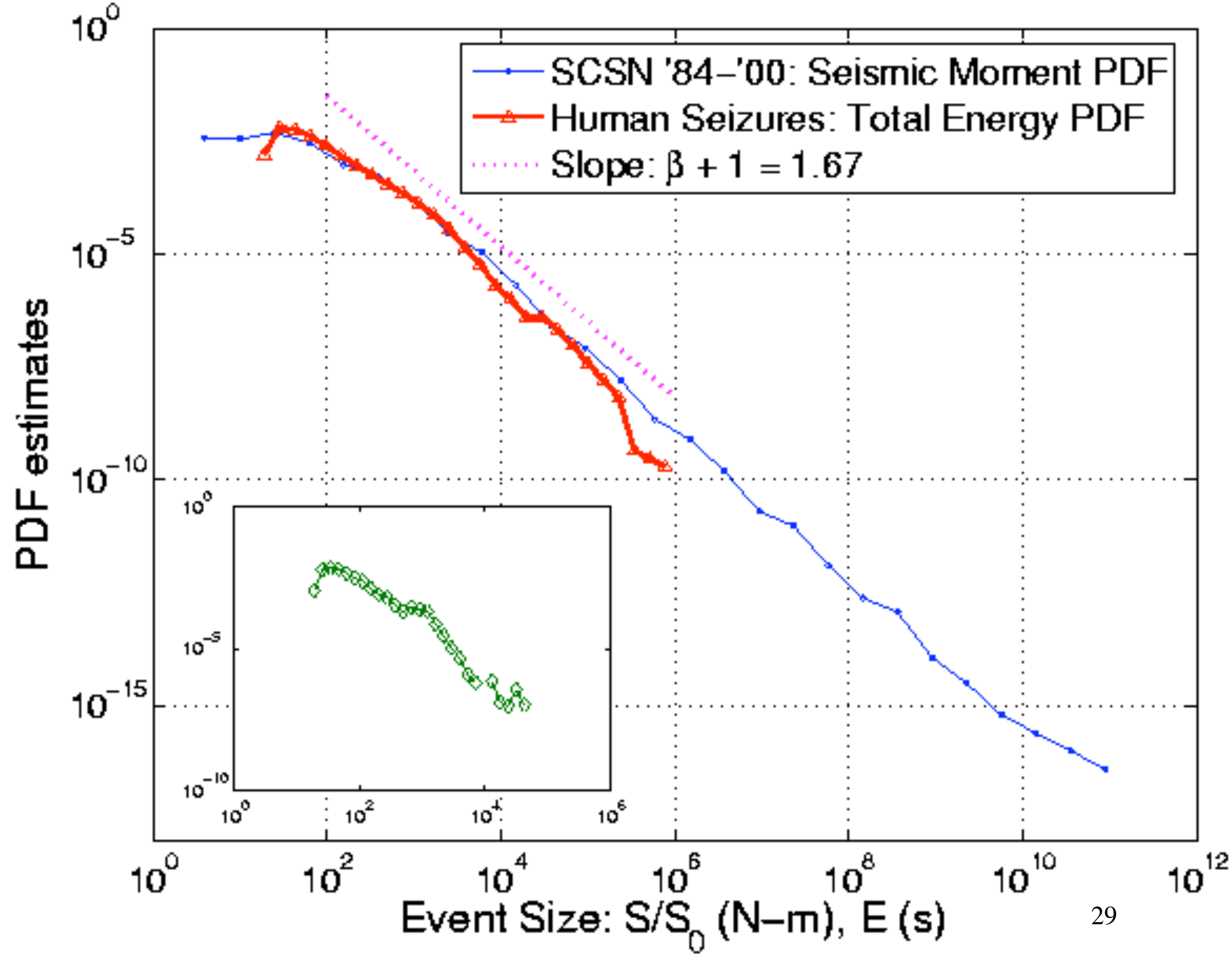
Key: L=Left
R=Right
A=Anterior
M=Mesial
P=Posterior
D=Depth
T=Temporal
F=Frontal



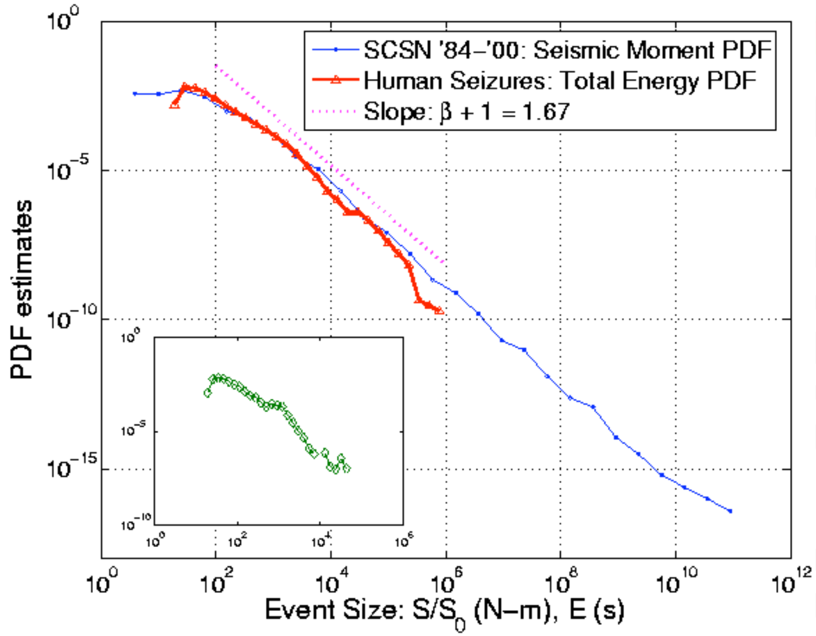
Bursts and Seizures



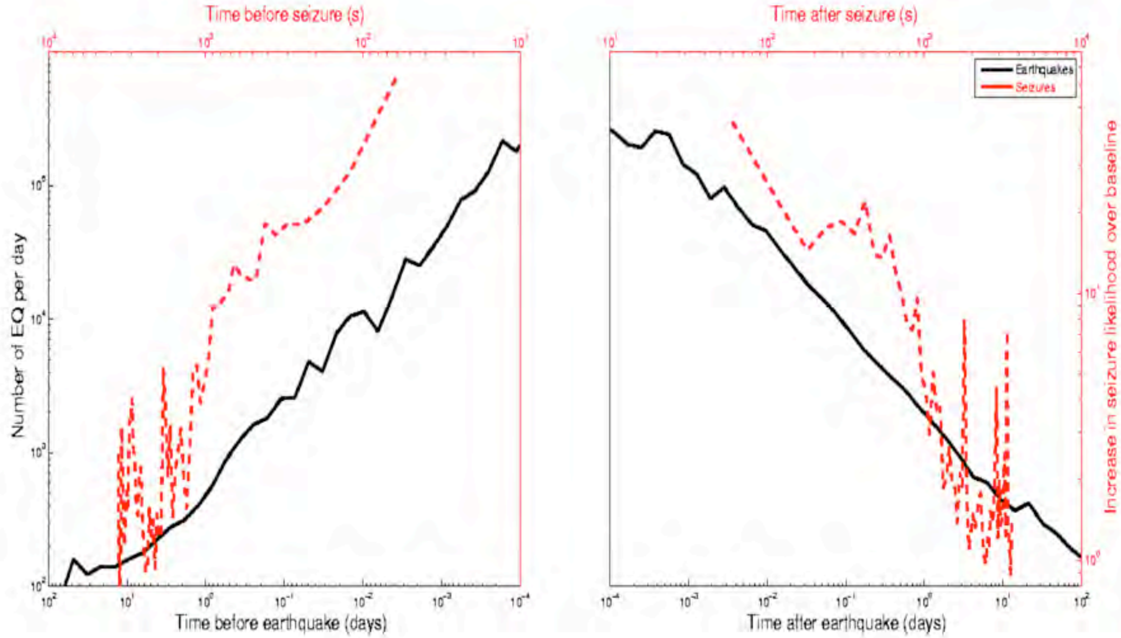
Gutenberg-Richter distribution of energies



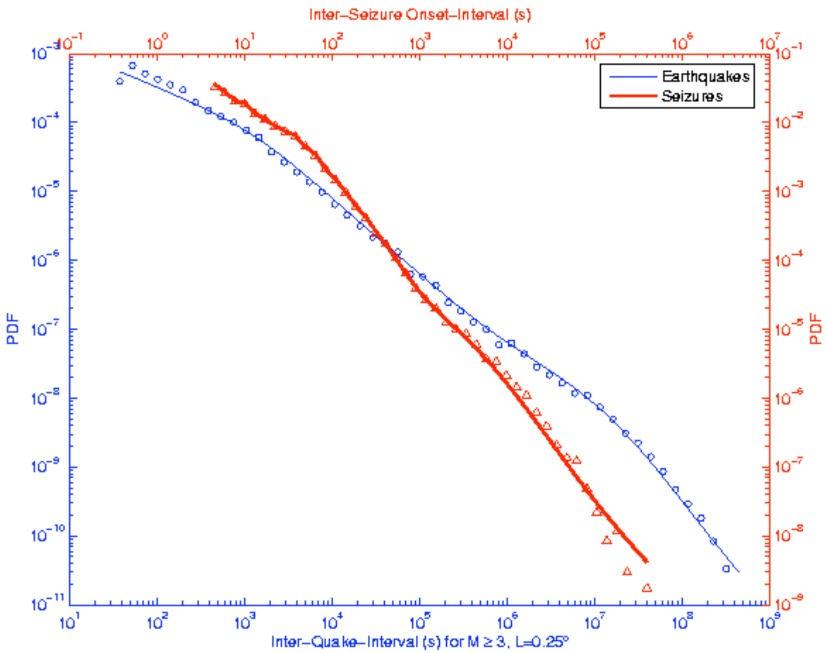
Gutenberg-Richter distribution of sizes



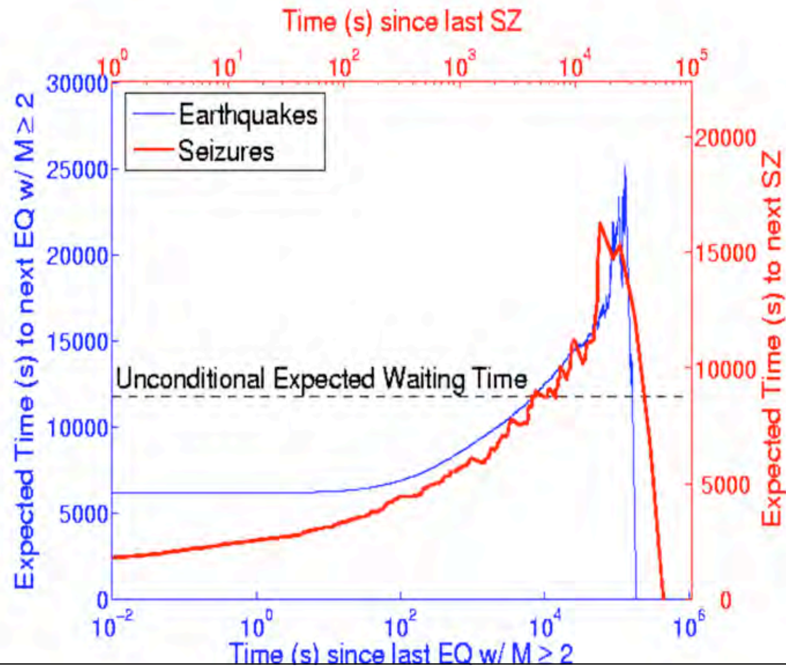
Omori law: Direct and Inverse



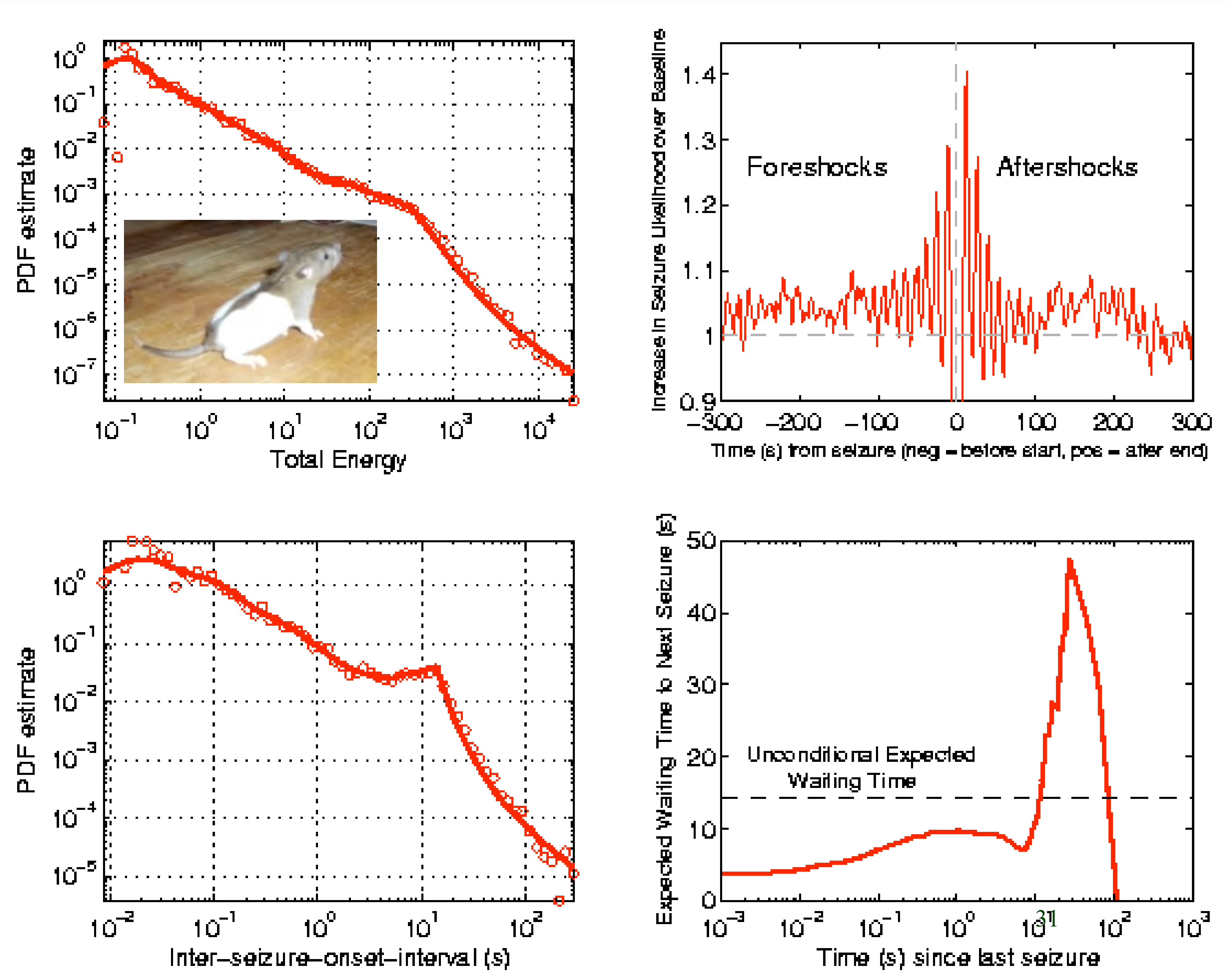
pdf of inter-event waiting times



The longer it has been since the last event,
the longer it will be since the next one!



19 rats treated intravenously (2) with the convulsant 3-mercapto-proprionic acid (3-MPA)



Landau-Ginzburg Theory of Self-Organized Criticality

Dynamics of an order parameter (OP) and of the corresponding *control* parameter (CP): within the sandpile picture, $\frac{\partial h}{\partial x}$ is the slope of the sandpile, h being the local height, and S is the state variable distinguishing between static grains ($S = 0$) and rolling grains ($S \neq 0$).

L. Gil and D. Sornette "Landau-Ginzburg theory of self-organized criticality", Phys. Rev.Lett. 76, 3991-3994 (1996)

Normal form of sub-critical bifurcation

$$\frac{\partial S}{\partial t} = \chi \{\mu S + 2\beta S^3 - S^5\} \tag{1}$$

where

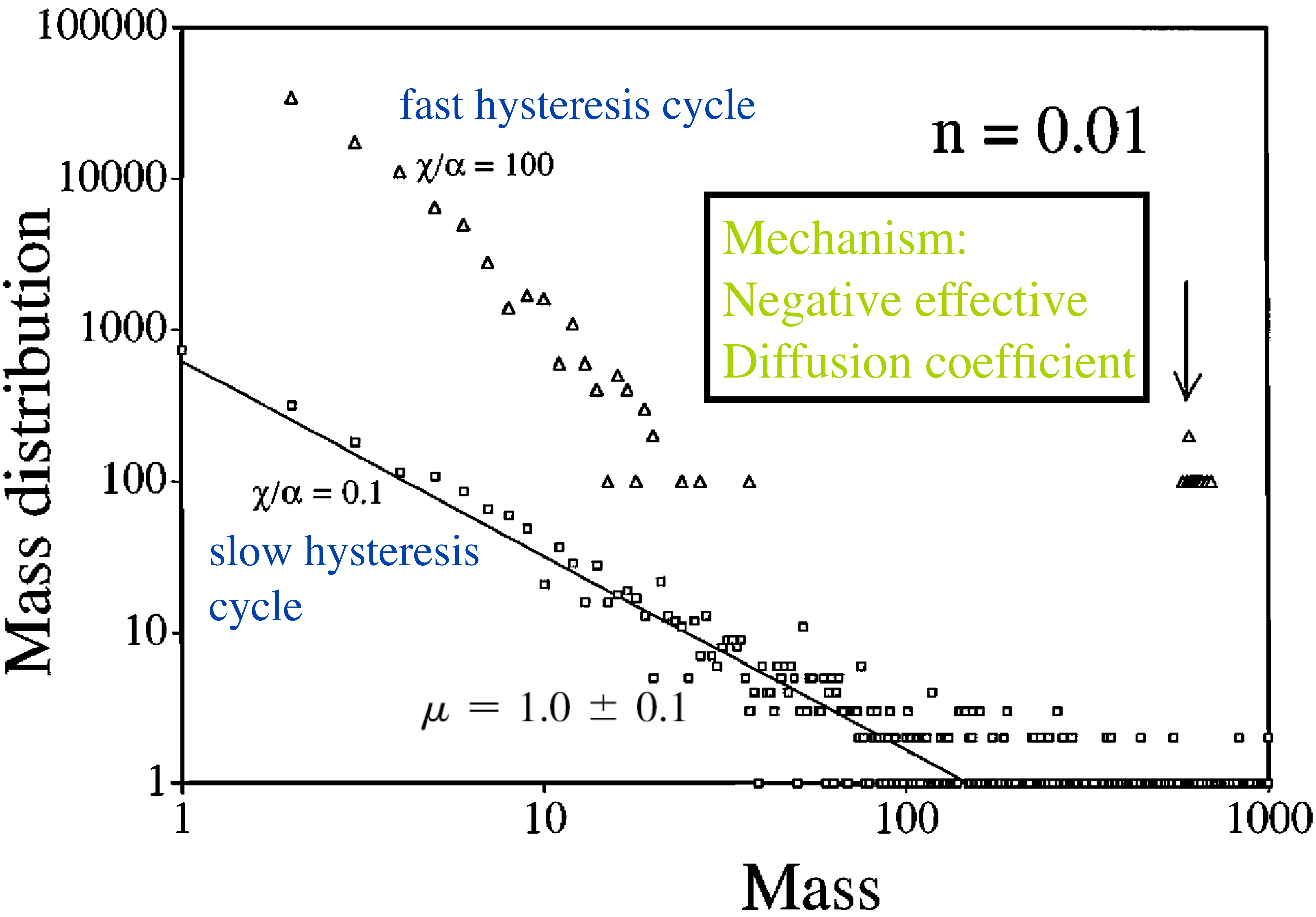
$$\mu = \left[\left(\frac{\partial h}{\partial x}\right)^2 - \left(\frac{\partial h}{\partial x}\Big|_c\right)^2\right] \tag{2}$$

and $\beta > 0$ (subcritical condition).

$$F\left(S, \frac{\partial h}{\partial x}\right) = -\alpha \frac{\partial h}{\partial x} S^2, \qquad \alpha > 0$$

Diffusion equation

$$\frac{\partial h}{\partial t} = -\frac{\partial F\left(S, \frac{\partial h}{\partial x}\right)}{\partial x} + \Phi \tag{3}$$



System sizes range from $L/a = 64$ to 2048.

$$P(M)dM \simeq M^{-(1+\mu)}dM,$$

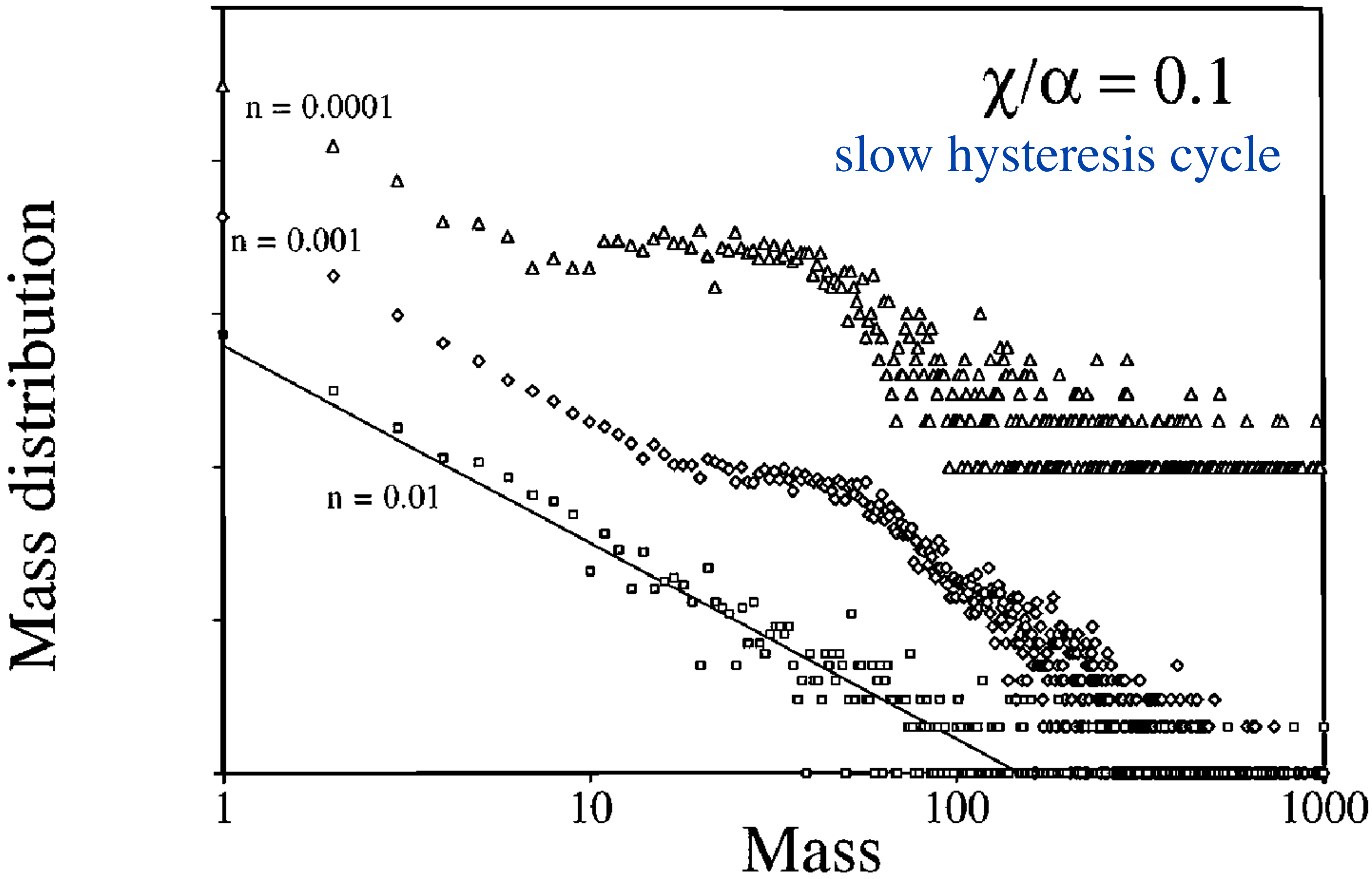


FIG. 2. Distributions $P(M)$ of avalanche sizes for the same $\chi/\alpha = 0.1$ but decreasing values, from bottom to top, of the noise. The curves have been moved with respect to each other for better clarity.

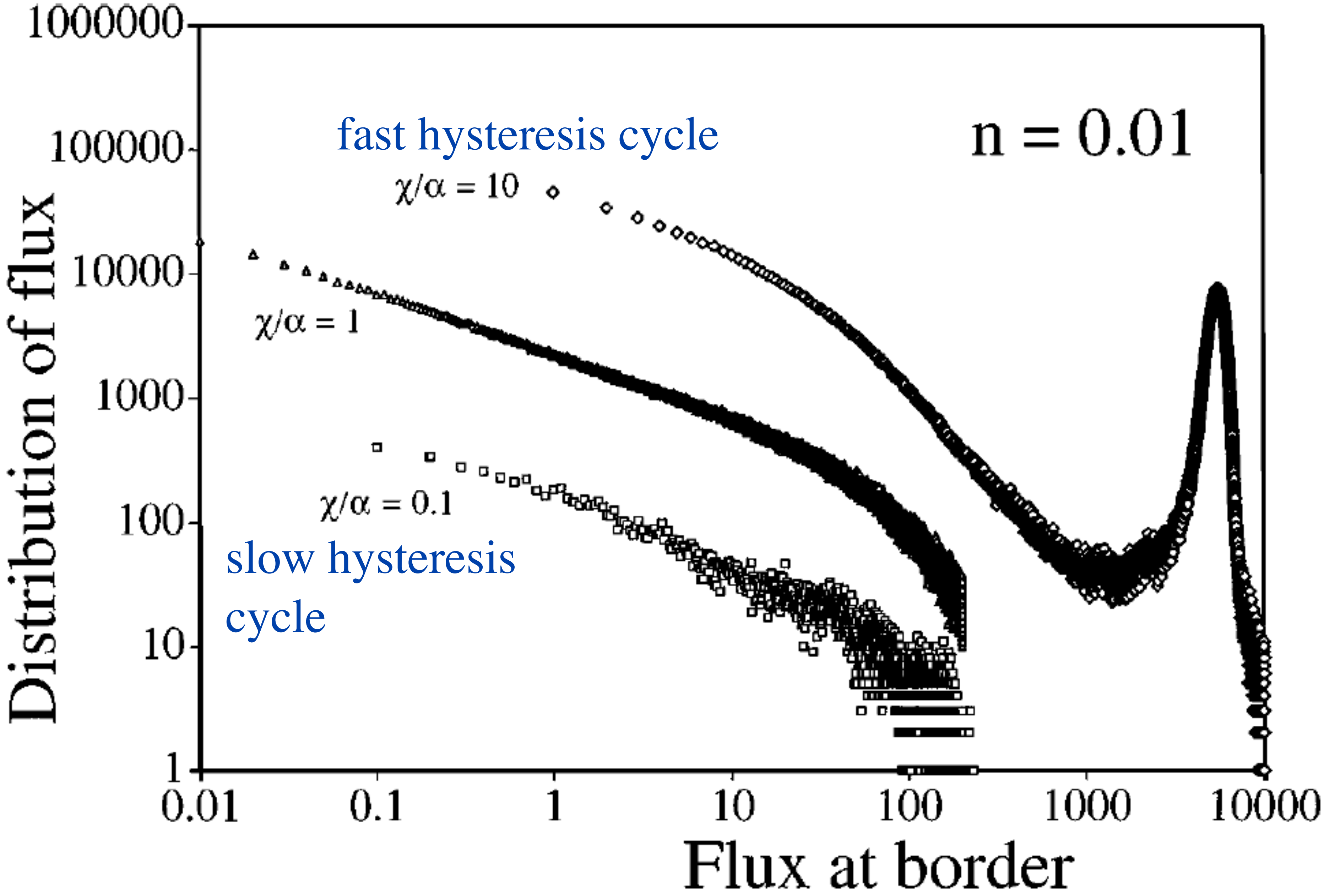
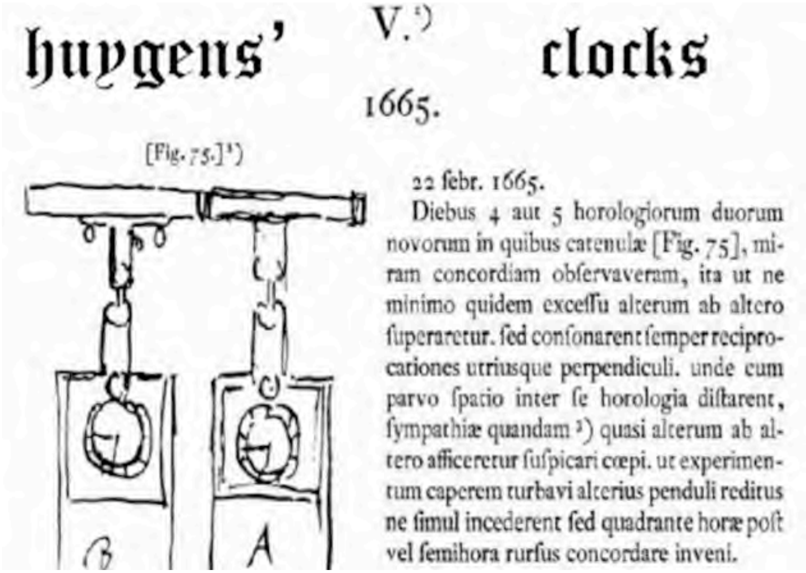


FIG. 3. Distribution $P(J)$ of flux amplitudes at the right border, in the same conditions as for Fig. 1.

SYNCHRONISATION AND COLLECTIVE EFFECTS IN EXTENDED STOCHASTIC SYSTEMS



huygens' V.[1] clocks

1665.

[Fig. 75.][1]

22 febr. 1665.

Diebus 4 aut 5 horologiorum duorum novorum in quibus catenulæ [Fig. 75], miram concordiam obſervaveram, ita ut ne minimo quidem exceſſu alterum ab altero ſuperaretur. ſed conſonarent ſemper reciprocationes utriusque perpendiculi. unde cum parvo ſpatio inter ſe horologia diſtarent, ſympathiæ quandam [2]) quasi alterum ab altero afficeretur ſuſpicari cœpi. ut experimentum caperem turbavi alterius penduli reditus ne ſimul incederent ſed quadrante horæ poſt vel ſemihora rurſus concordare inveni.

Fireflies

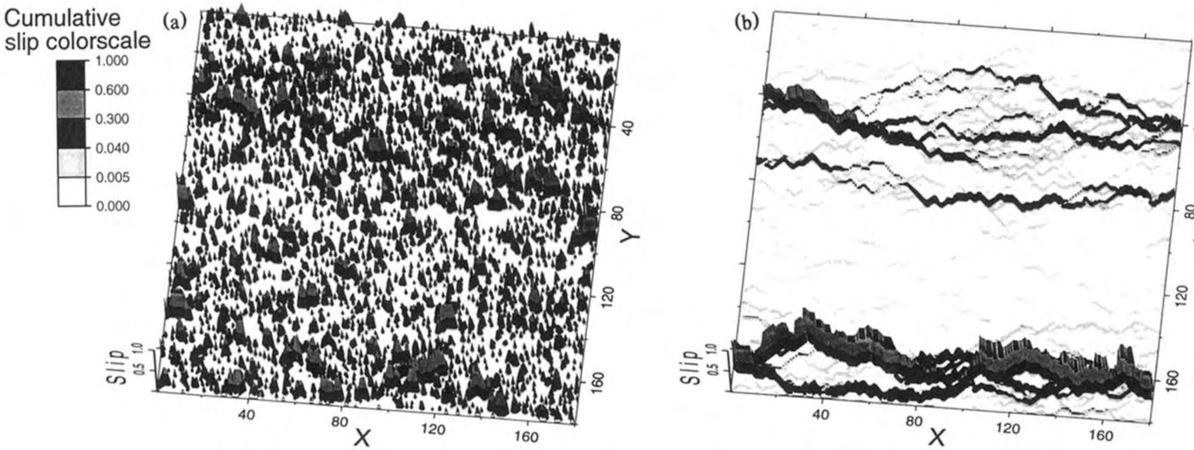
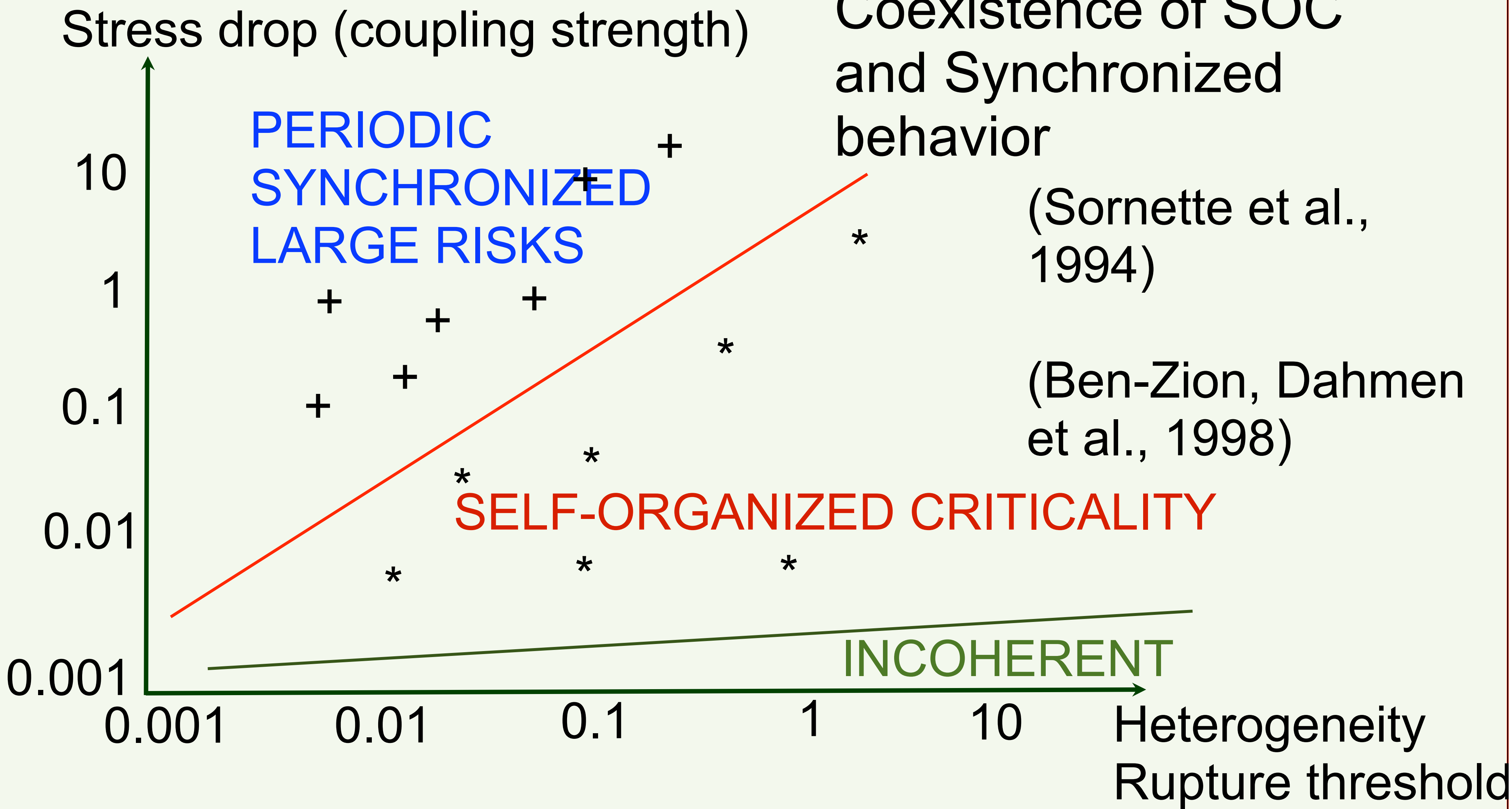


FIG. 1. Evolution of the cumulative earthquake slip, represented along the vertical axis in the white to black color code shown above the picture, at two different times: (a) early time and (b) long time, in a system of size $L=90$ by $L=90$, where $\Delta\sigma=1.9$ and $\beta=0.1$.

Miltenberger et al. (1993)

Coexistence of SOC and Synchronized behavior



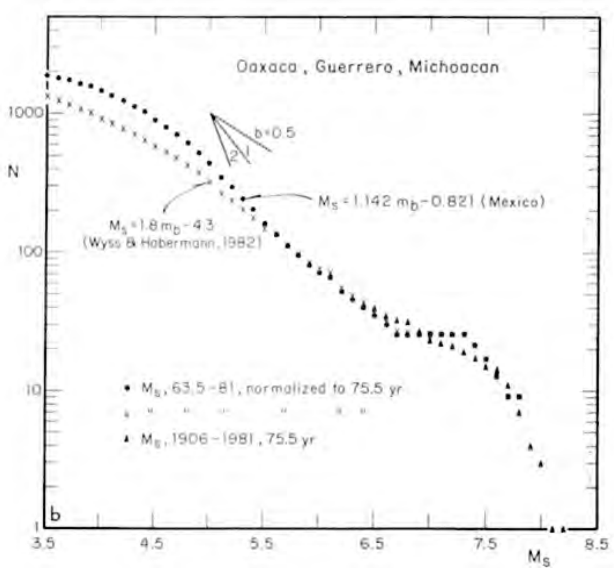
(Sornette et al., 1994)

(Ben-Zion, Dahmen et al., 1998)

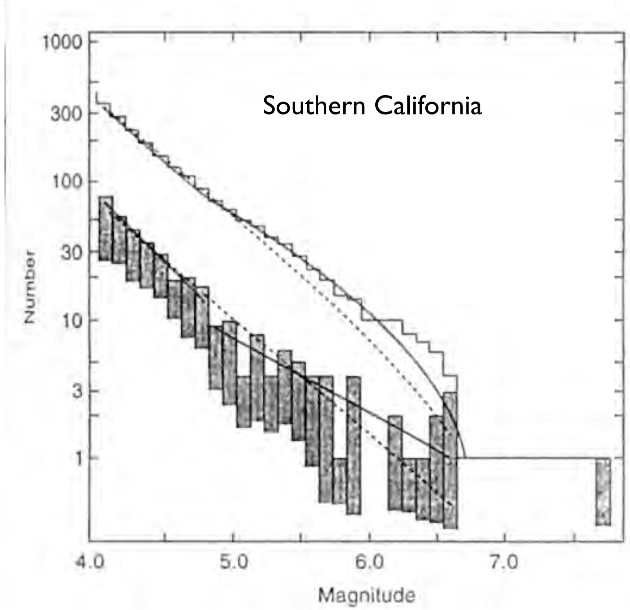
“Phase diagram” for the model in the space (heterogeneity, stress drop). Crosses (+) correspond to systems which exhibit a periodic time evolution. Stars * corresponds to systems that are self-organized critical, with a Gutenberg-Richter earthquake size distribution and fault localization whose geometry is well-described by the geometry of random directed polymers.

Complex magnitude distributions

Characteristic earthquakes?



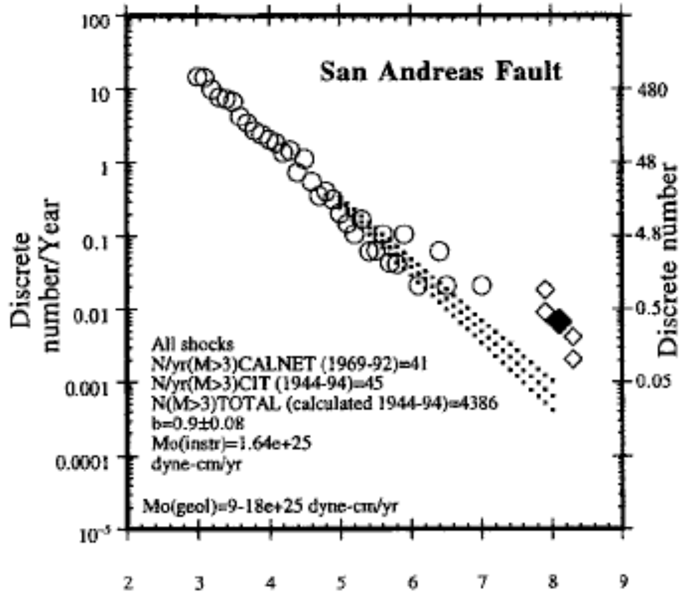
Singh, et. al., 1983, BSSA 73, 1779-1796

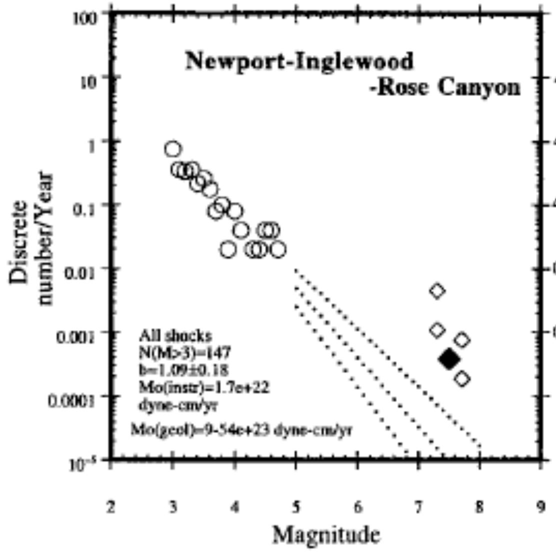


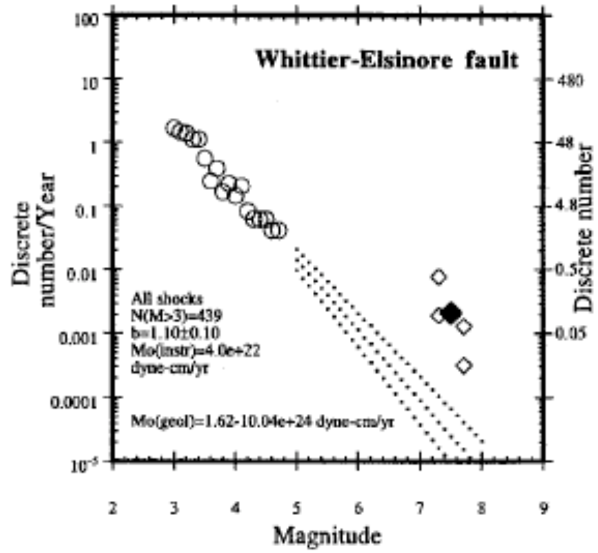
Knopoff, 2000, PNAS 97, 11880-11884

Main, 1995, BSSA 85, 1299-1308

Wesnousky, 1996, BSSA 86, 286-291







Predictability of catastrophic events: Material rupture, earthquakes, turbulence, financial crashes, and human birth

2522–2529 | PNAS | February 19, 2002 | vol. 99 | suppl. 1

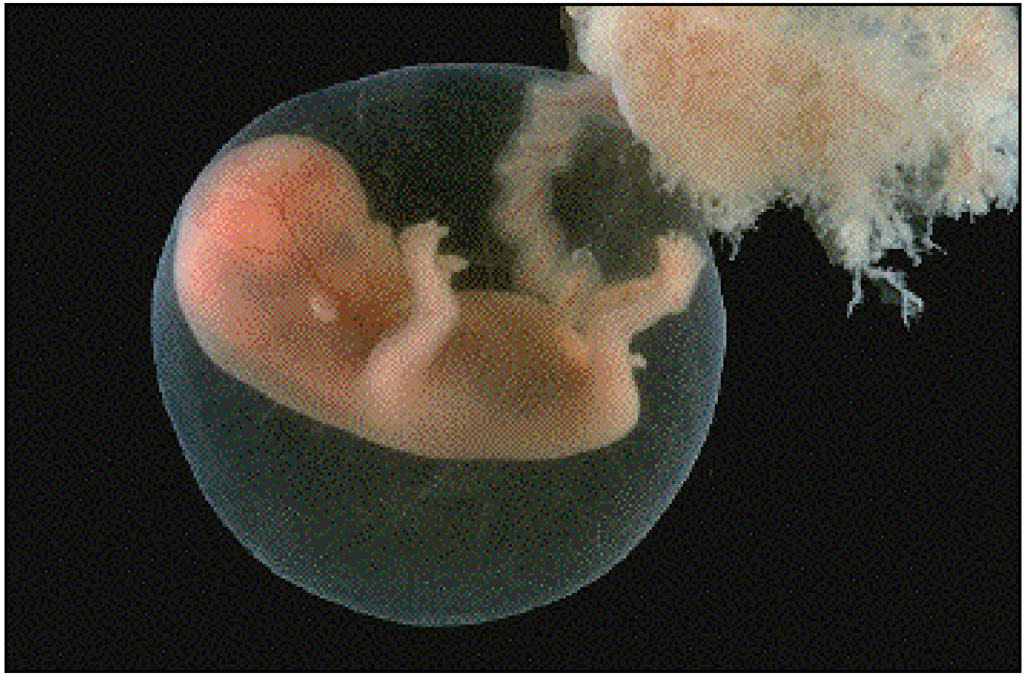
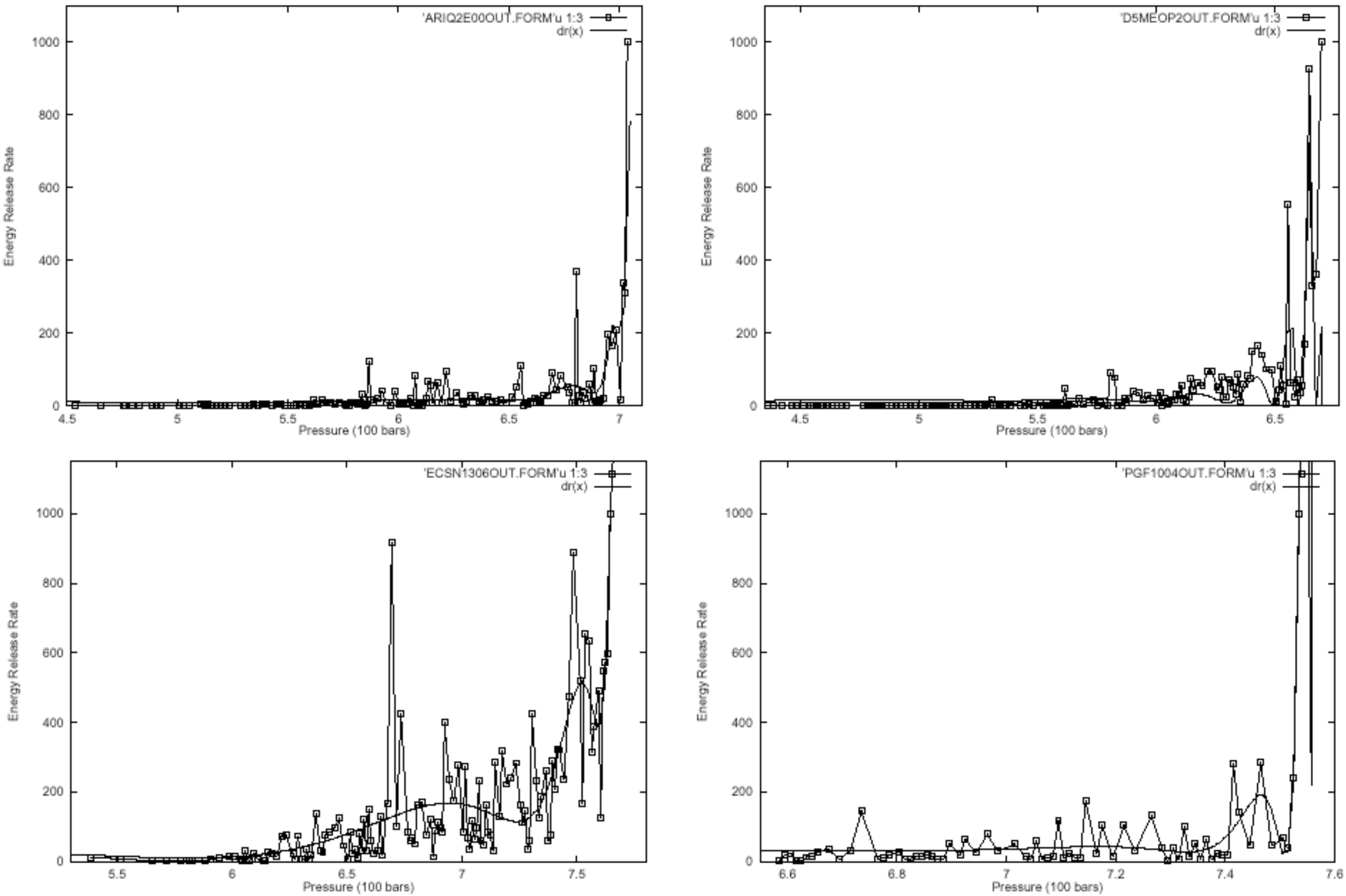


Figure 1: Ariane 5 composite high pressure tanks

Our prediction system is now used in the industrial phase as the standard testing procedure.

EADS LAUNCH VEHICLES

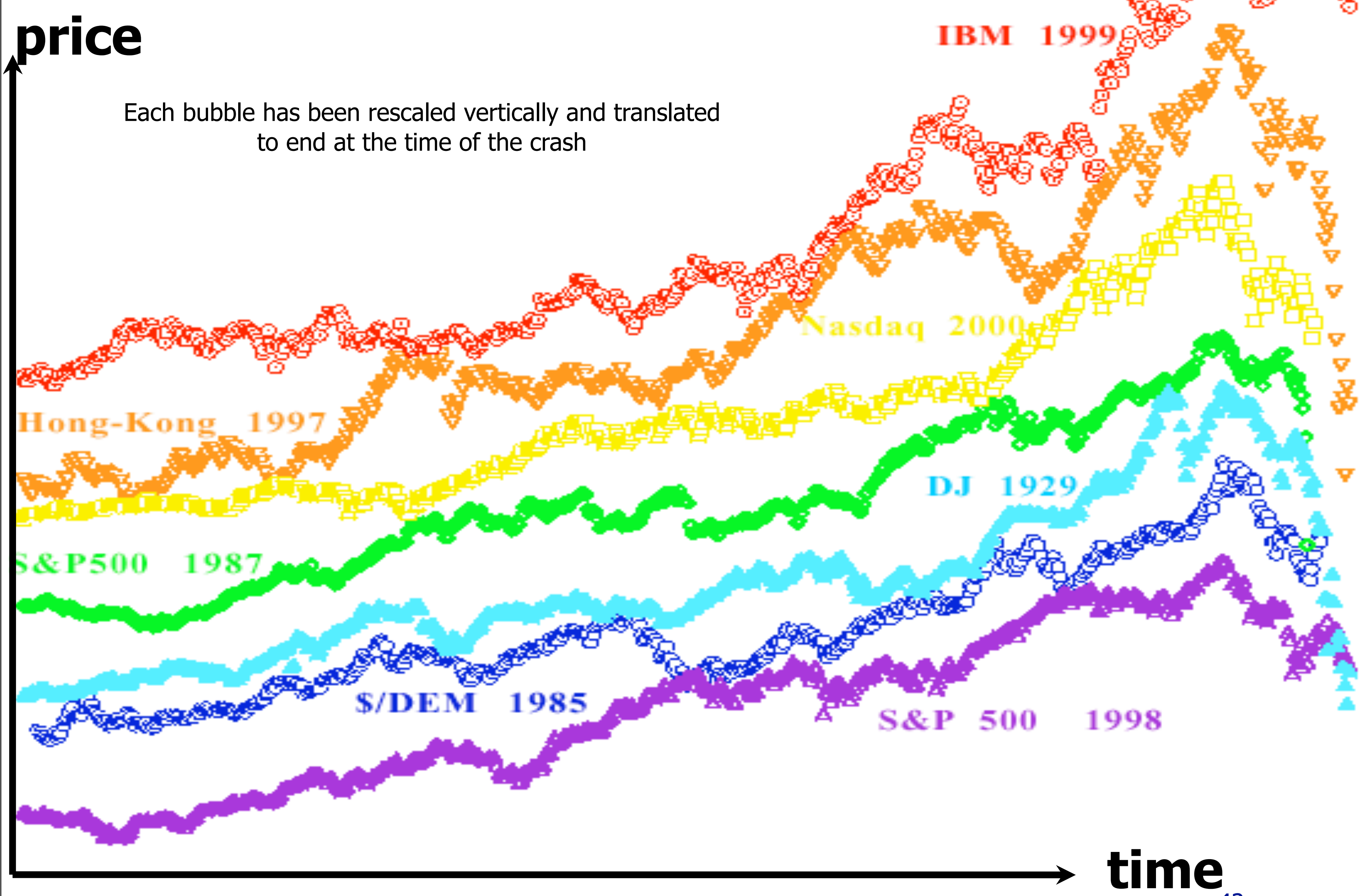
J.-C. Anifrani, C. Le Floc'h, D. Sornette and B. Souillard
"Universal Log-periodic correction to renormalization group scaling for rupture stress prediction from acoustic emissions", J.Phys.I France 5, n°6, 631-638 (1995)

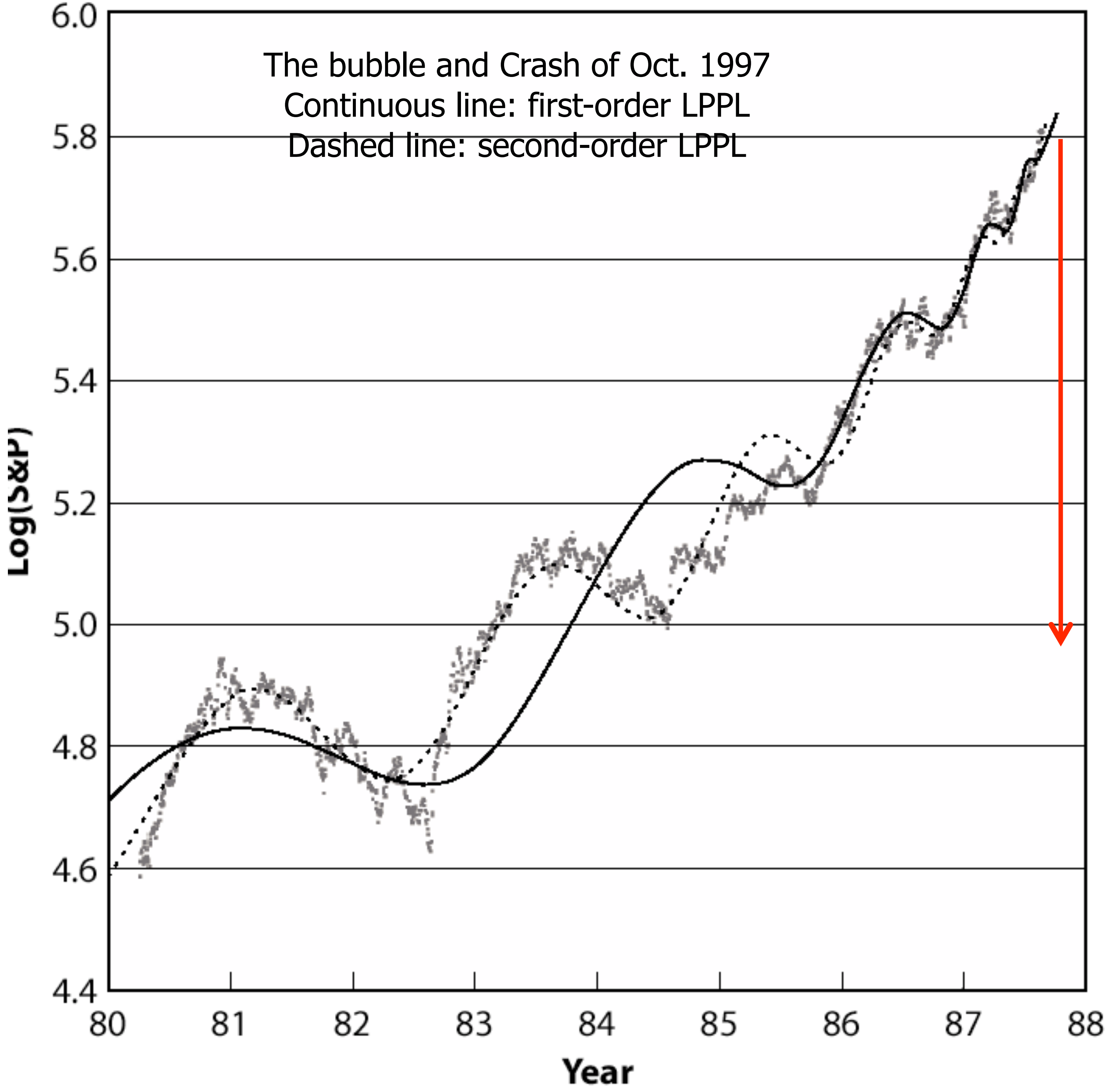


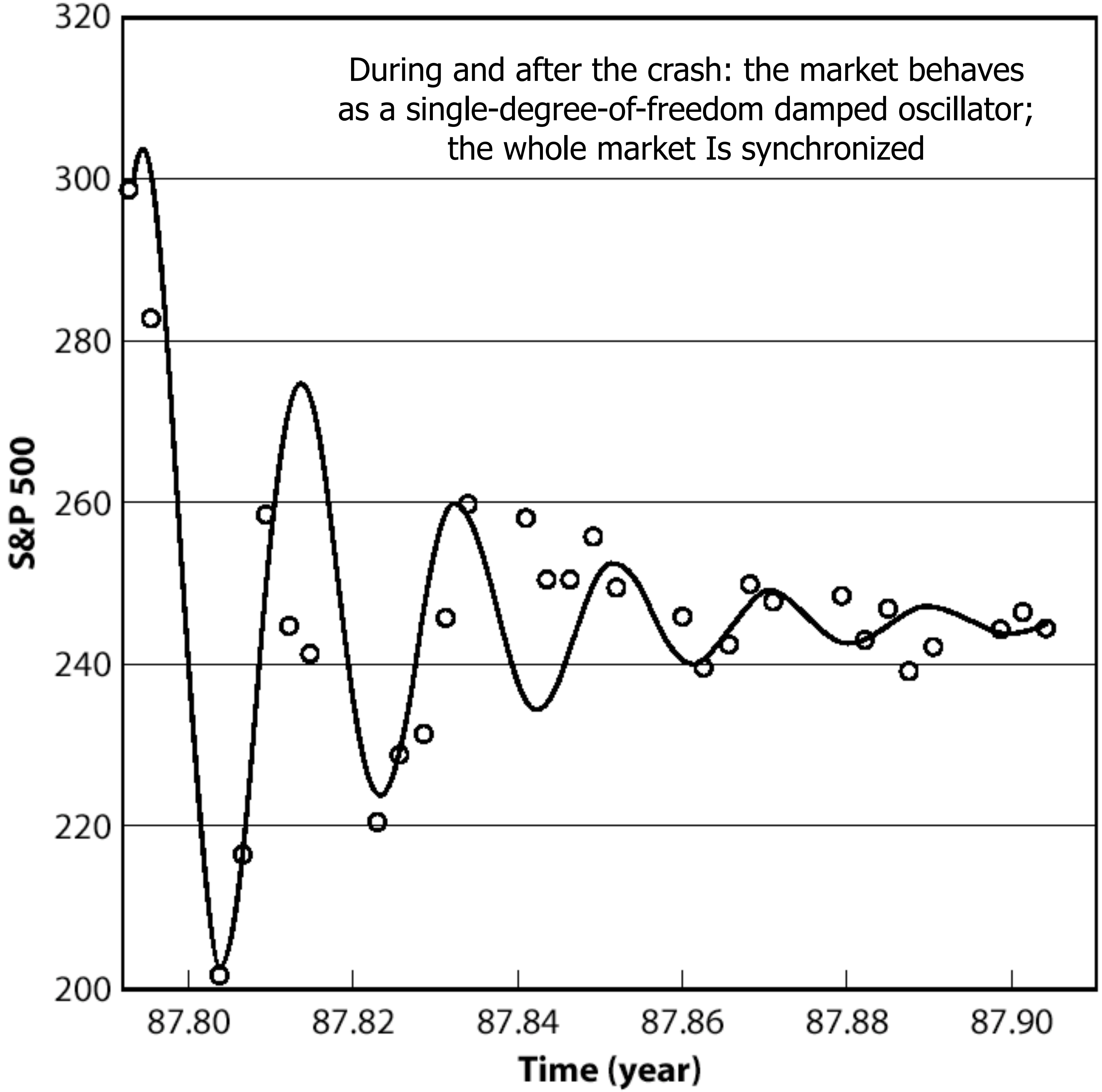
Critical ruptures

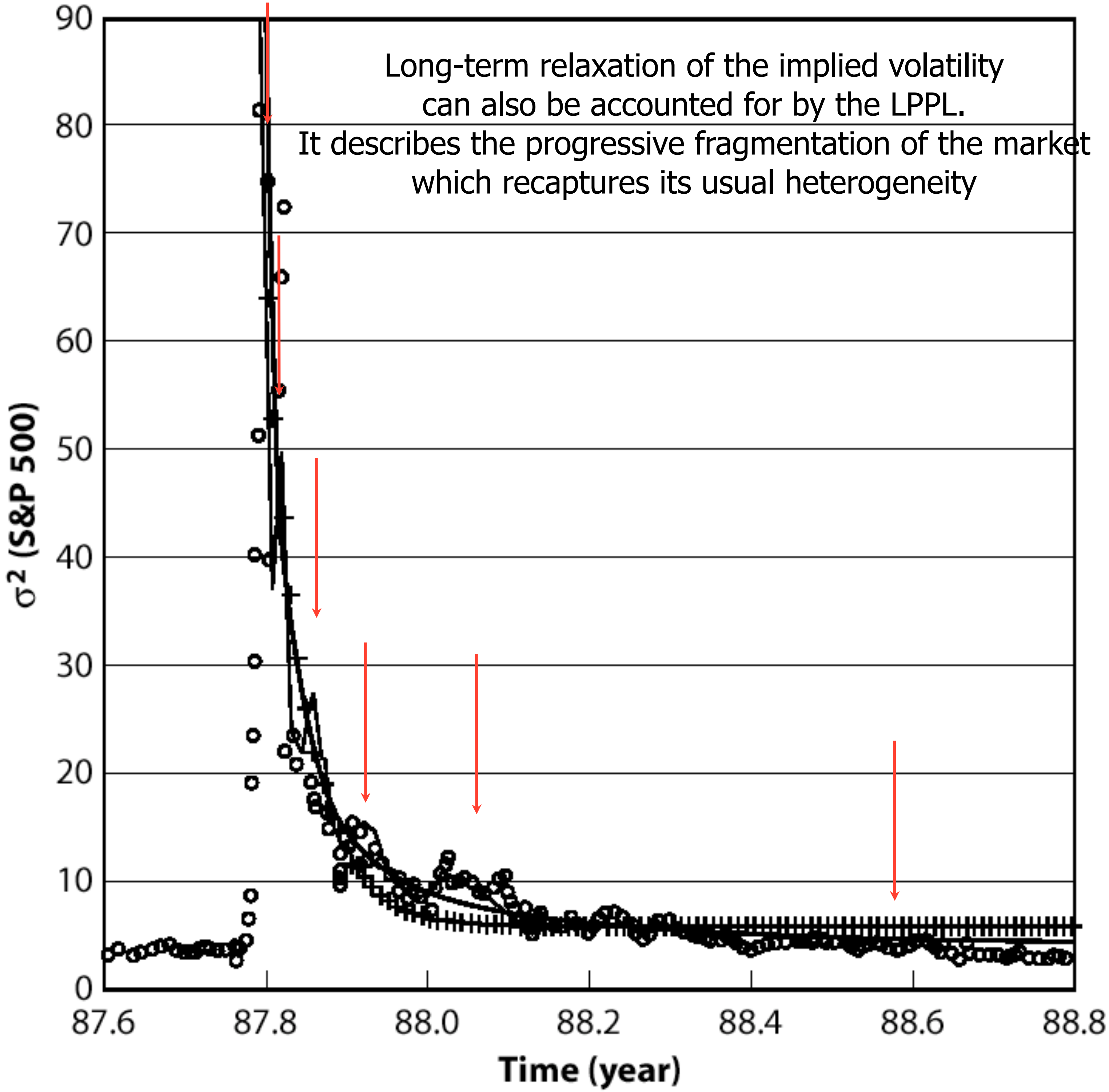
A. Johansen[1] and D. Sornette[1] Eur. Phys. J. B **18**, 163–181 (2000)

Various Bubbles and Crashes




The bubble and Crash of Oct. 1997
Continuous line: first-order LPPL
Dashed line: second-order LPPL
Log(S&P)
6.0
5.8
5.6
5.4
5.2
5.0
4.8
4.6
4.4
80
81
82
83
84
85
86
87
88
Year


During and after the crash: the market behaves
as a single-degree-of-freedom damped oscillator;
the whole market Is synchronized
S&P 500
320
300
280
260
240
220
200
87.80
87.82
87.84
87.86
87.88
87.90
Time (year)


Long-term relaxation of the implied volatility
can also be accounted for by the LPPL.
It describes the progressive fragmentation of the market
which recaptures its usual heterogeneity
σ² (S&P 500)
90
80
70
60
50
40
30
20
10
0
87.6
87.8
88.0
88.2
88.4
88.6
88.8
Time (year)

Endogenous vs exogenous crashes

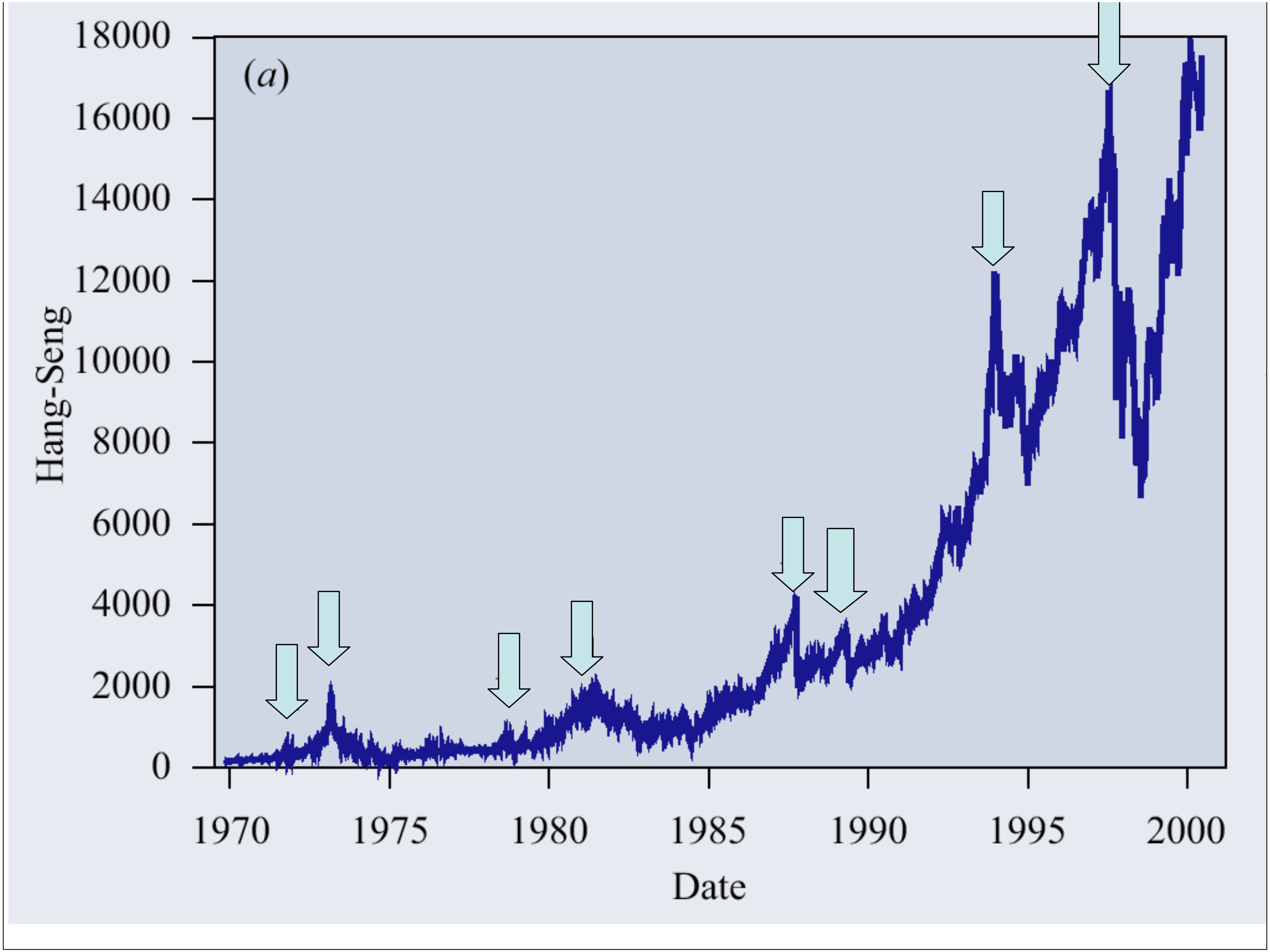
1. Systematic qualification of outliers/kings in pdfs of drawdowns

2. Existence or absence of a "critical" behavior by LPPL patterns found systematically in the price trajectories preceding this outliers

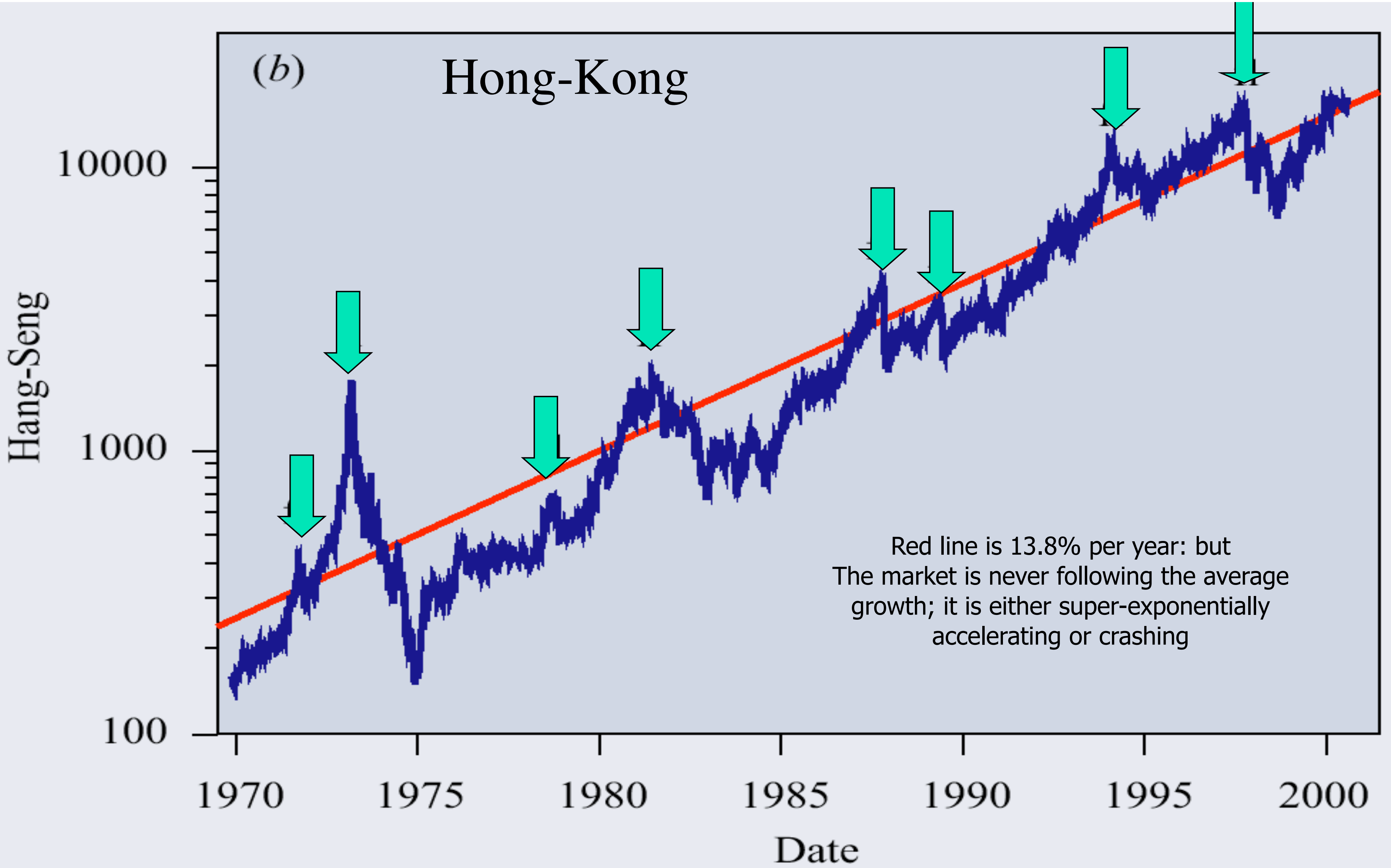
Results: In worldwide stock markets + currencies + bonds

- **21 endogenous crashes**
- **10 exogenous crashes**

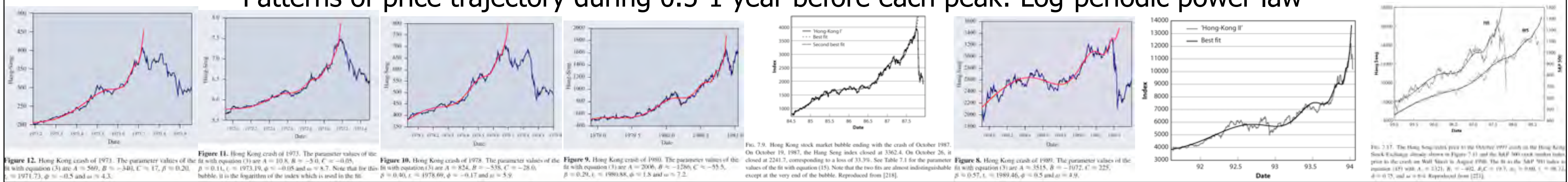
A. Johansen and D. Sornette,
Endogenous versus Exogenous Crashes in Financial Markets,
(http://arXiv.org/abs/cond-mat/0210509)



(a)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Hang-Seng
1970
1975
1980
1985
1990
1995
2000
Date

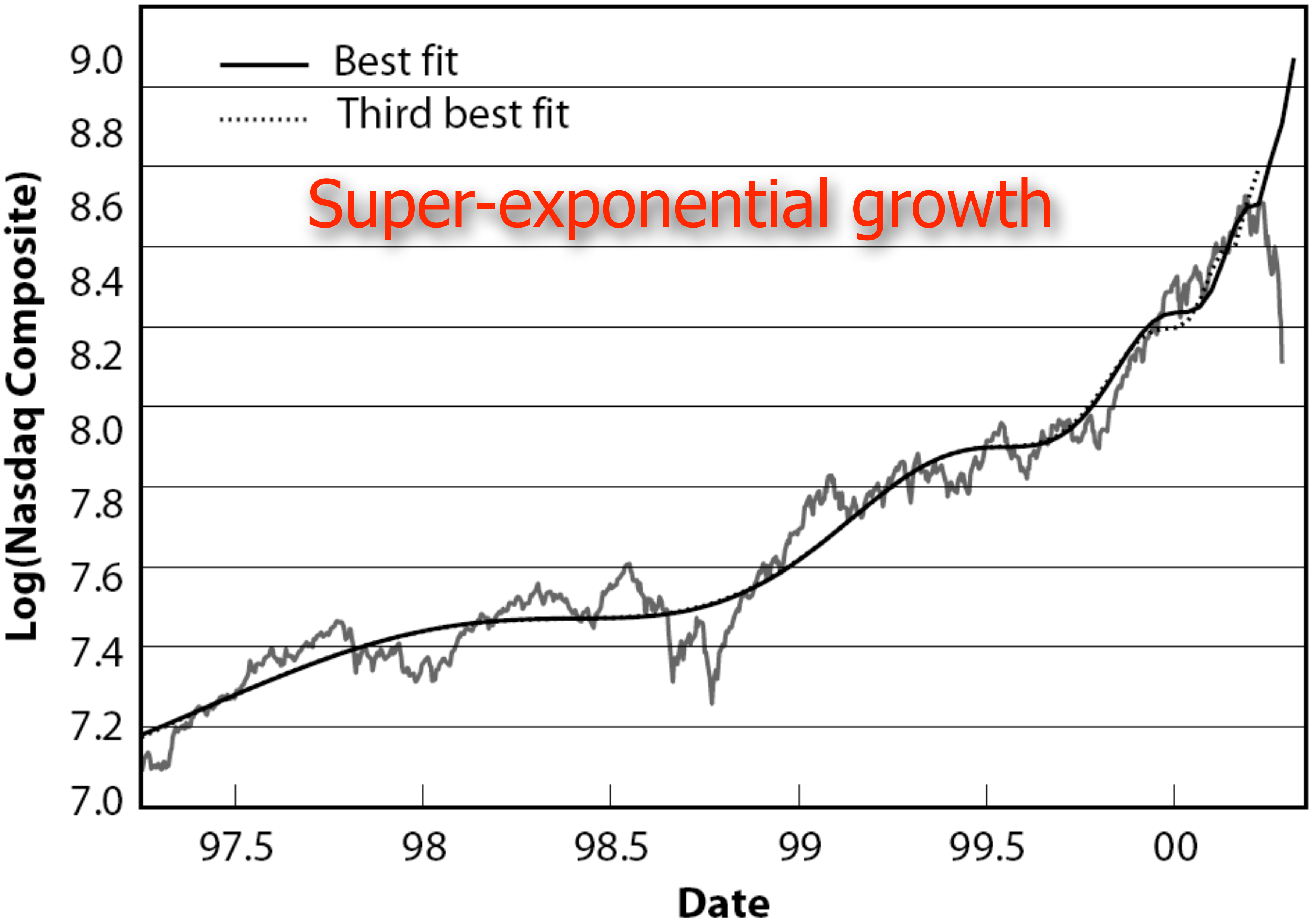


Patterns of price trajectory during 0.5-1 year before each peak: Log-periodic power law



THE NASDAQ CRASH OF APRIL 2000

"New Economy": ICT



Real-estate in the UK

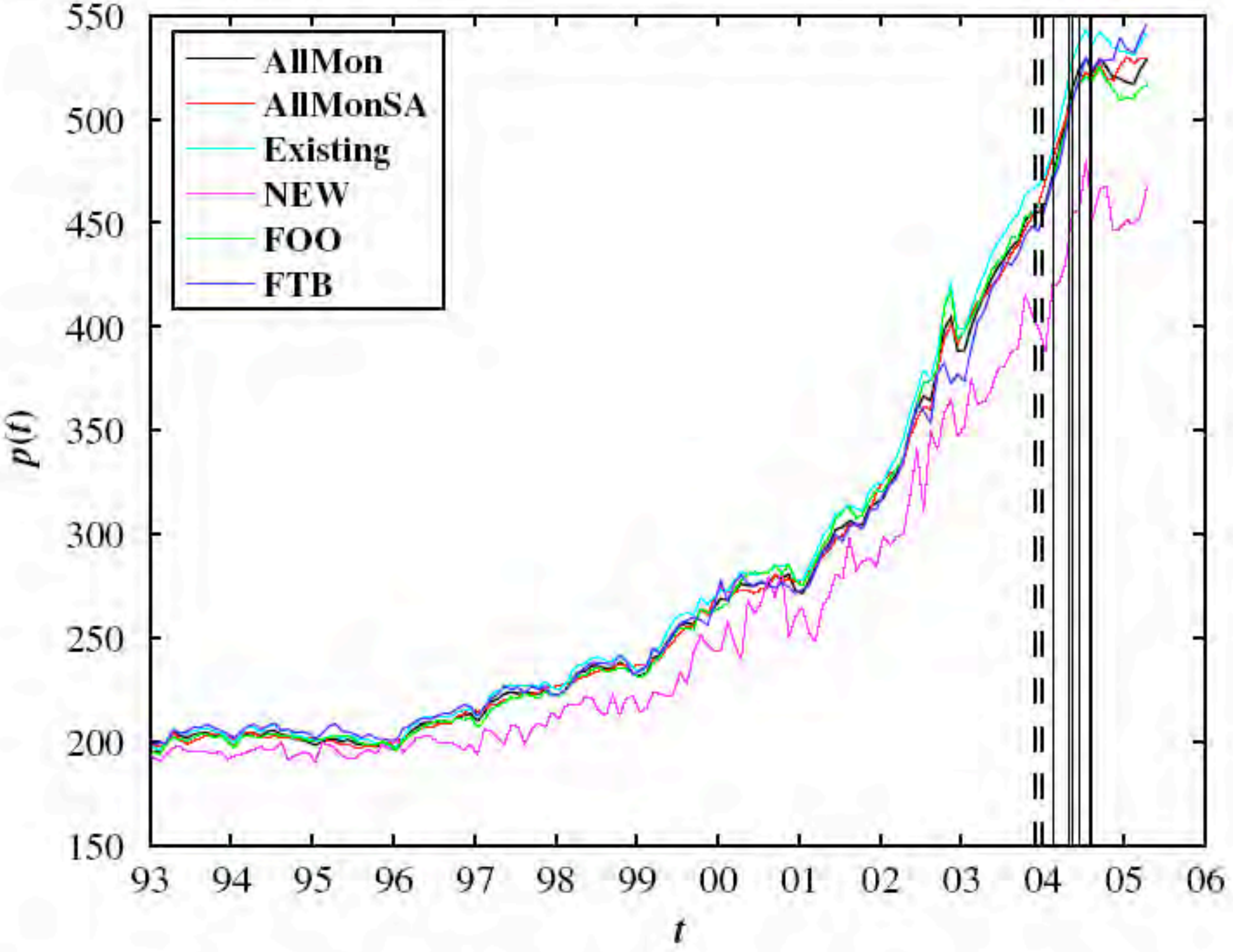


Fig. 1. (Color online) Plot of the UK Halifax house price indices from 1993 to April 2005 (the latest available quote at the time of writing). The two groups of vertical lines correspond to the two predicted turning points reported in Tables 2 and 3 of [1]: end of 2003 and mid-2004. The former (resp. later) was based on the use of formula (2) (resp. (3)). These predictions were performed in February 2003.

W.-X. Zhou, D. Sornette, 2000–2003 real estate bubble in the UK but not in the USA, Physica A 329 (2003) 249–263.

Real-estate in the USA

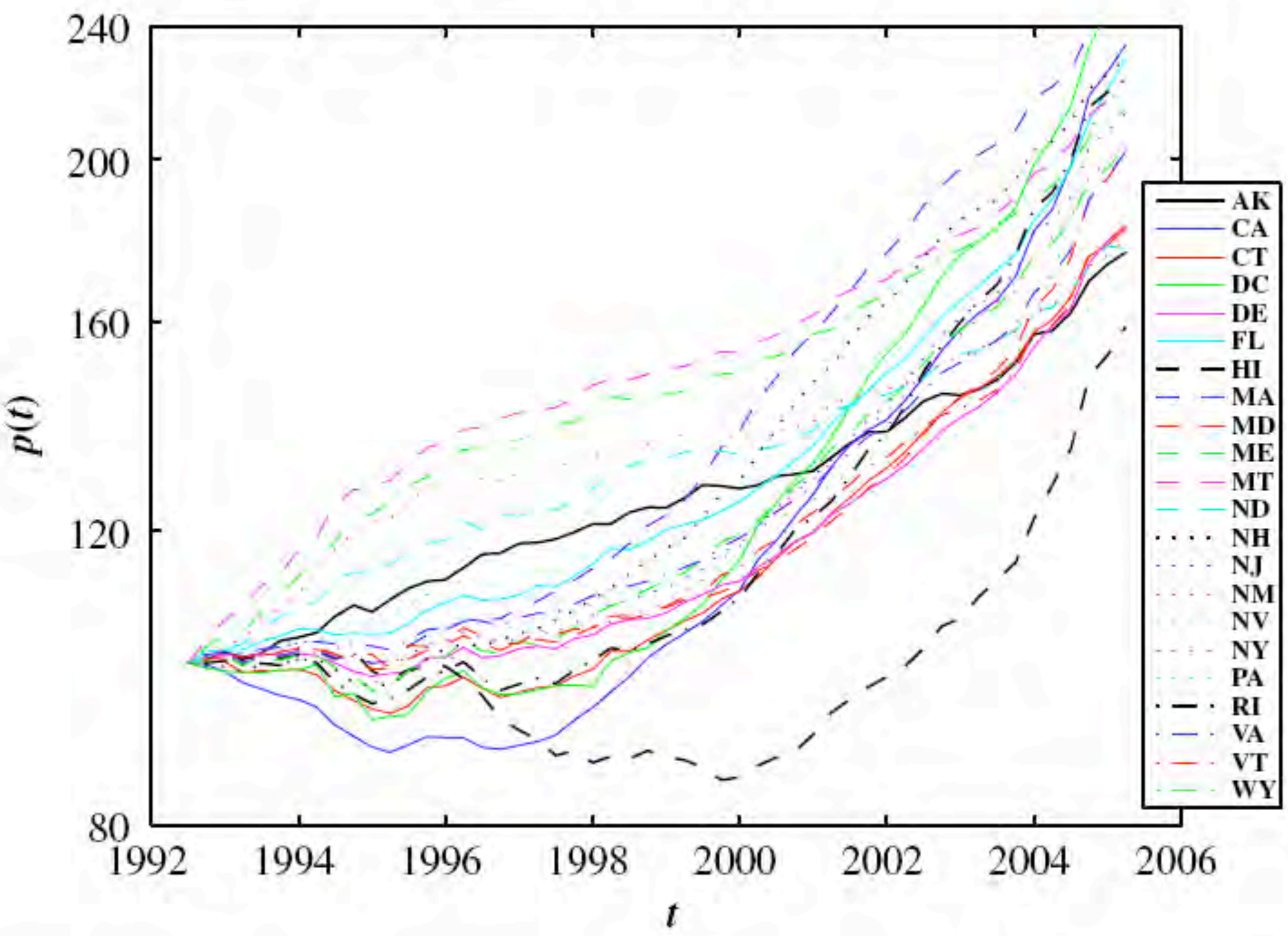
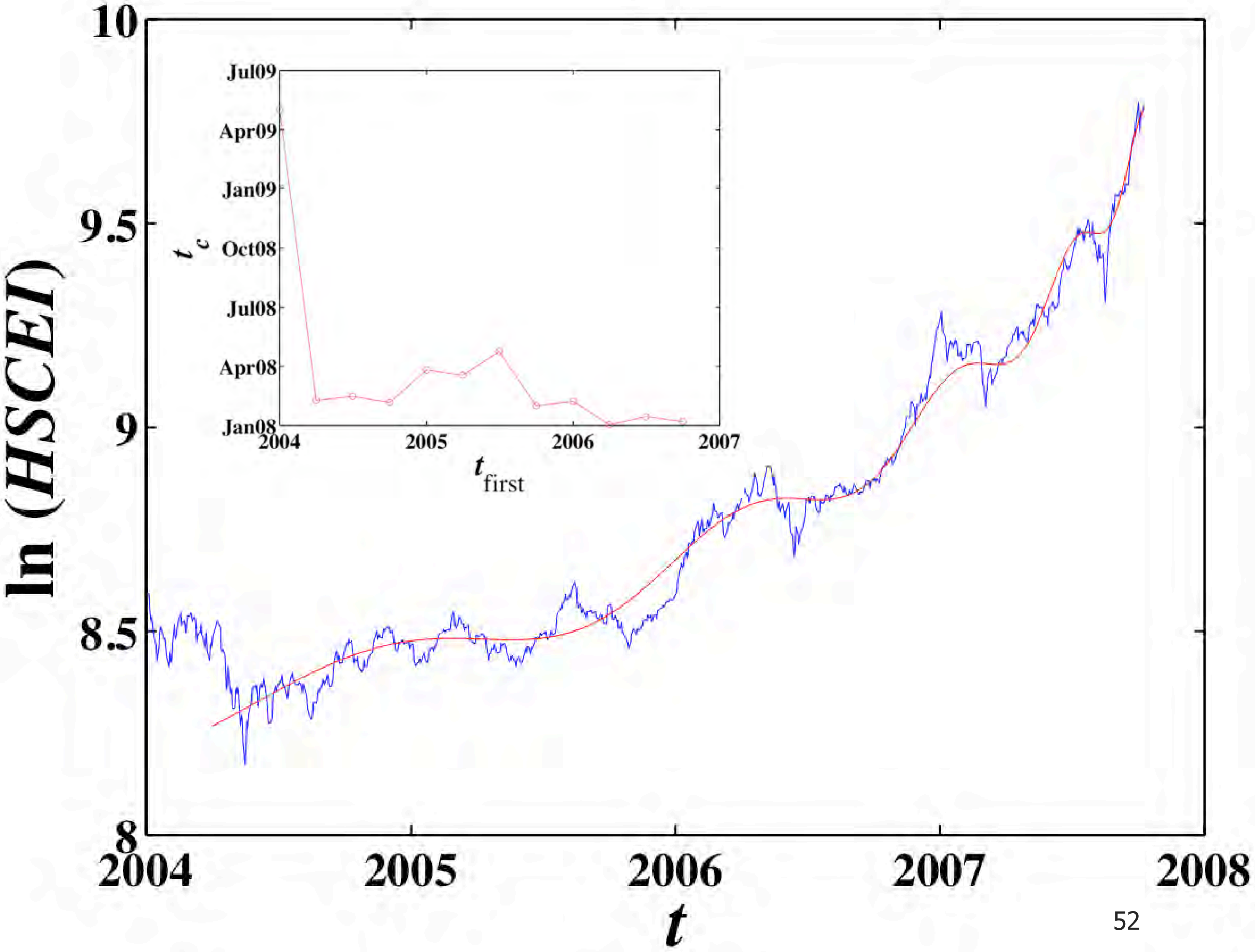


Fig. 5. (Color online) Quarterly average HPI in the 21 states and in the District of Columbia (DC) exhibiting a clear upward faster-than-exponential growth. For better representation, we have normalized the house price indices for the second quarter of 1992 to 100 in all 22 cases. The corresponding states are given in the legend.

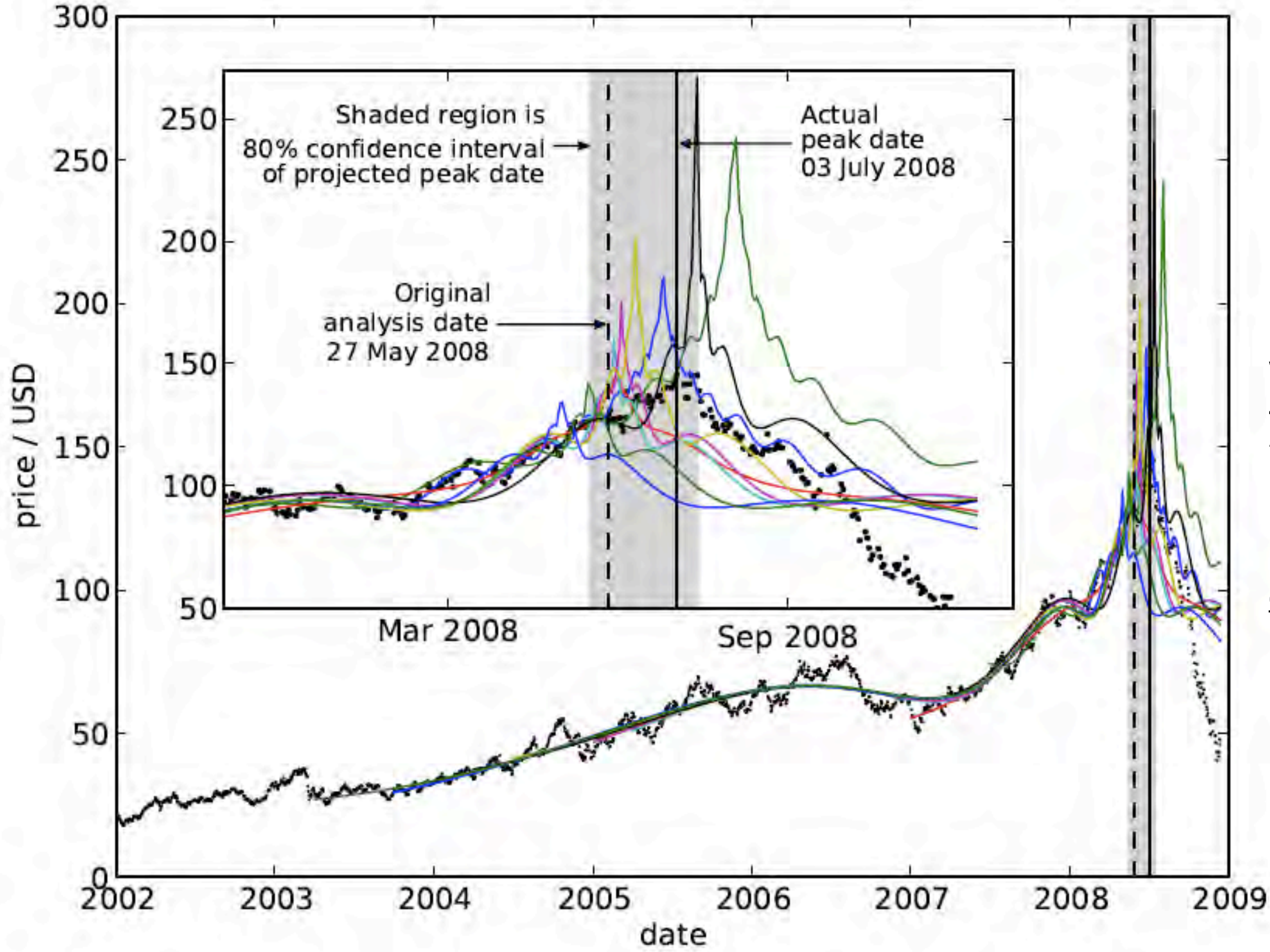
W.-X. Zhou, D. Sornette / Physica A 361 (2006) 297–308

Hang Seng China Entreprises Index (HSCEI)



source: Bloomberg

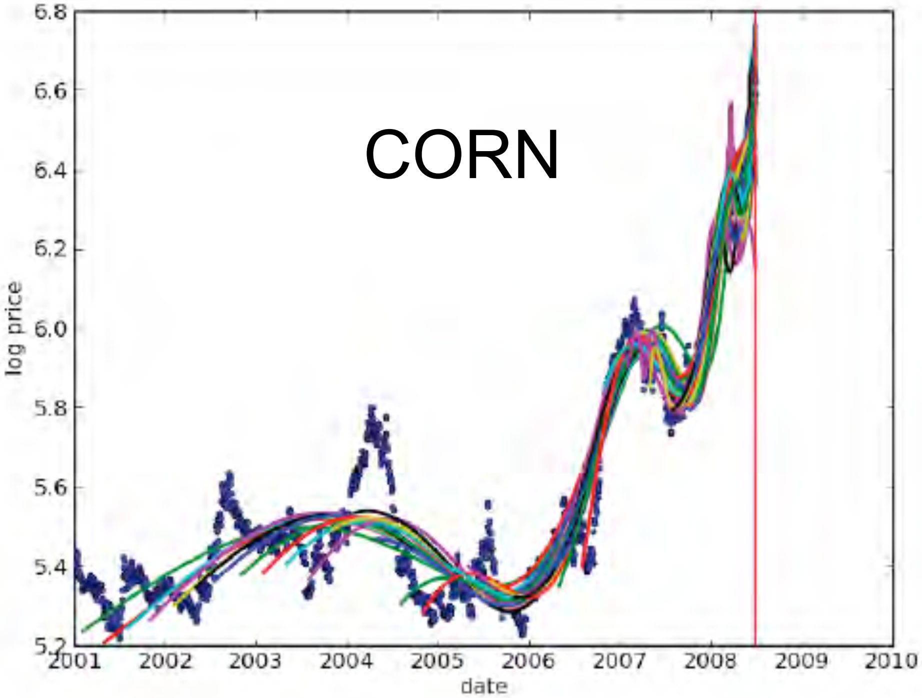
2006-2008 Oil bubble

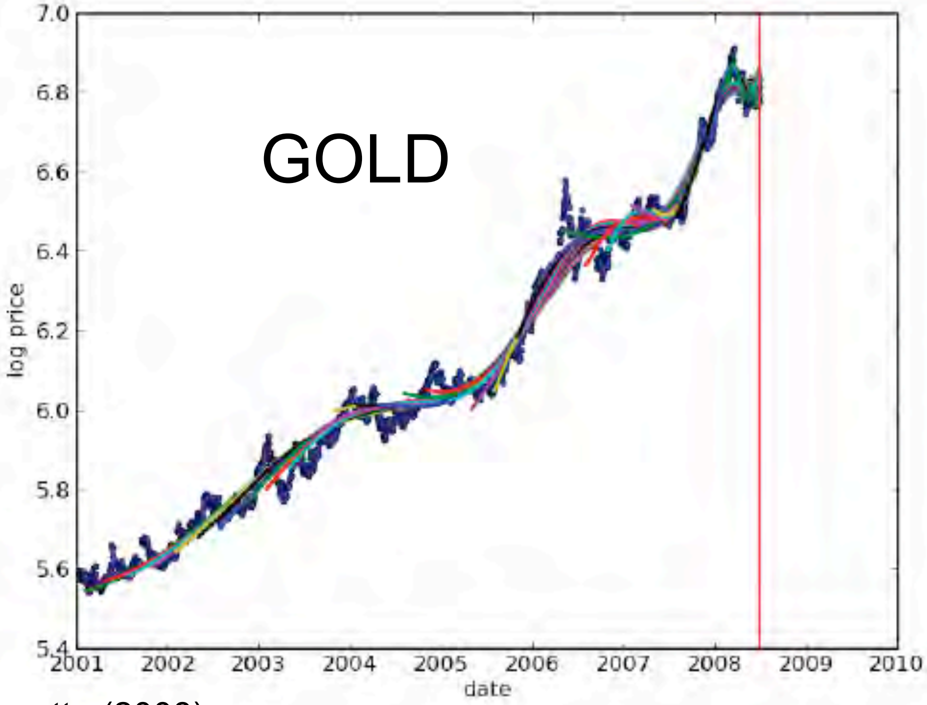


D. Sornette, R. Woodard and W.-X. Zhou, The 2006-2008 Oil Bubble and Beyond, Physica A 388, 1571-1576 (2009) (arXiv.org/abs/0806.1170)

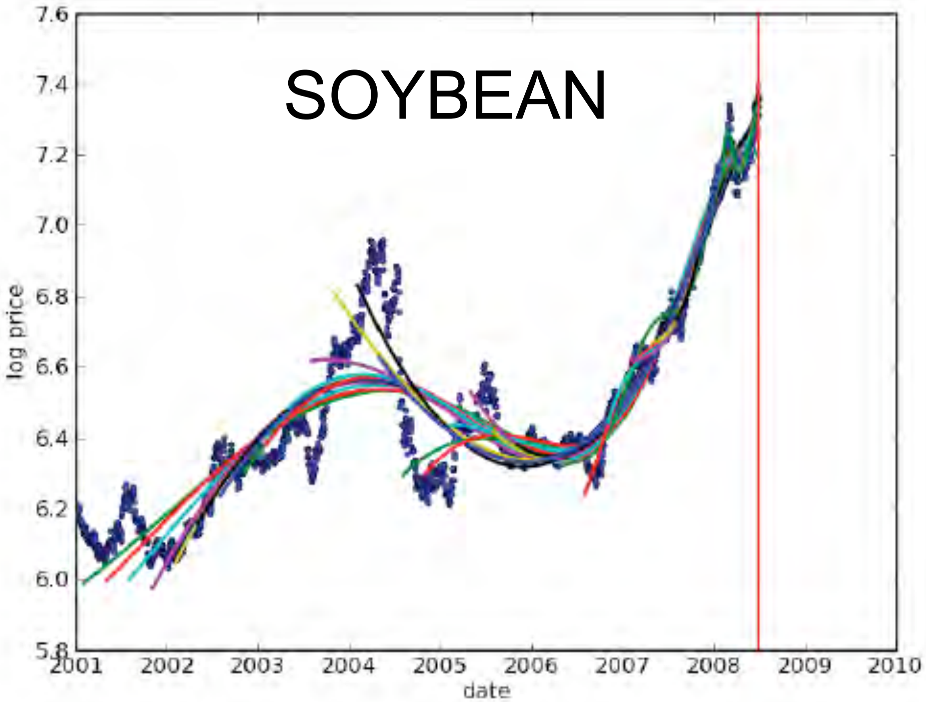
Typical result of the calibration of the simple LPPL model to the oil price in US$ in shrinking windows with starting dates t_{start} moving up towards the common last date t_{last} = May 27, 2008.

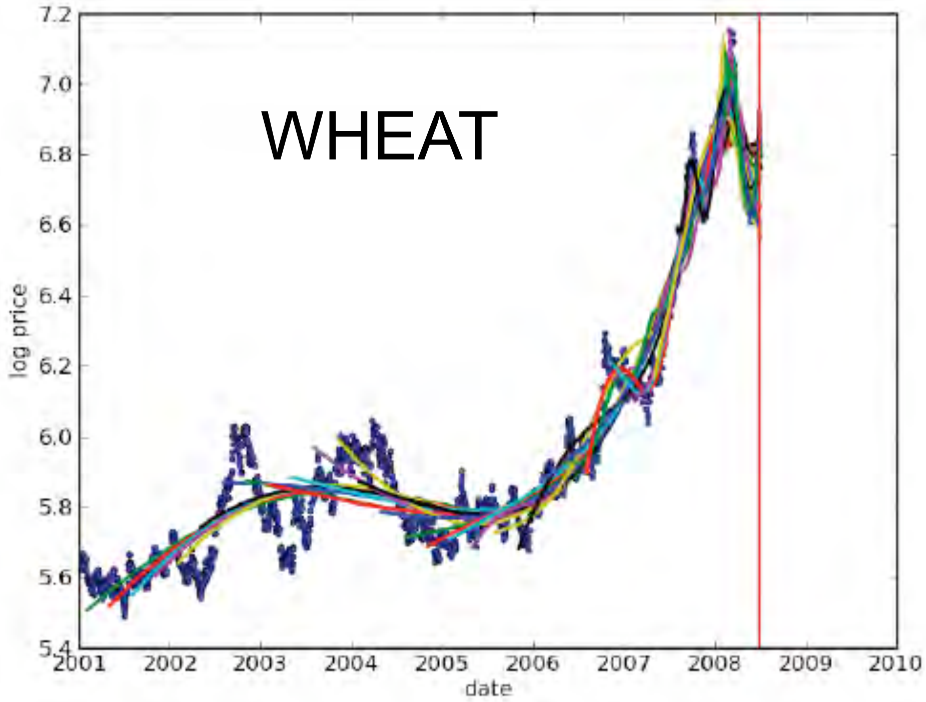
source: R. Woodard





R.Woodard and D.Sornette (2008)





The Financial Crisis Observatory

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

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- Description
- Highlights
- Is there an oil bubble?
- Predictions
  - Background
  - Real-Estate Predictions
  - Predictions about Society
  - Why Stock Markets Crash
- Pertinent articles
- Market Anxiety Measures

Predictions

This page is designed to be a forum for discussion on prediction issues in complex systems in which our own productions and thoughts as well as those of others are listed.

- Background - A discussion of prediction issues in complex systems
- Real-Estate Predictions
- Predictions about Society

Also see the following links:
The Institute For The Future

- a defense of trans-disciplinarity

- out-of-equilibrium view of the world (economics, geosciences, biology...)

- extreme events are the rule rather than the exception. Their study reveal important new mechanisms.

- the question of prediction

Systemic Risks

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ETH Zurich, Switzerland

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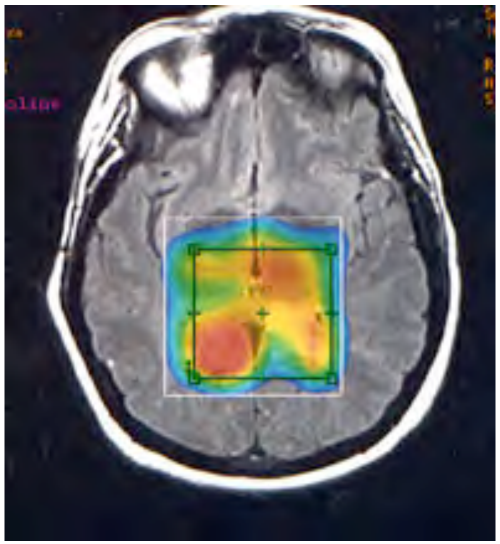
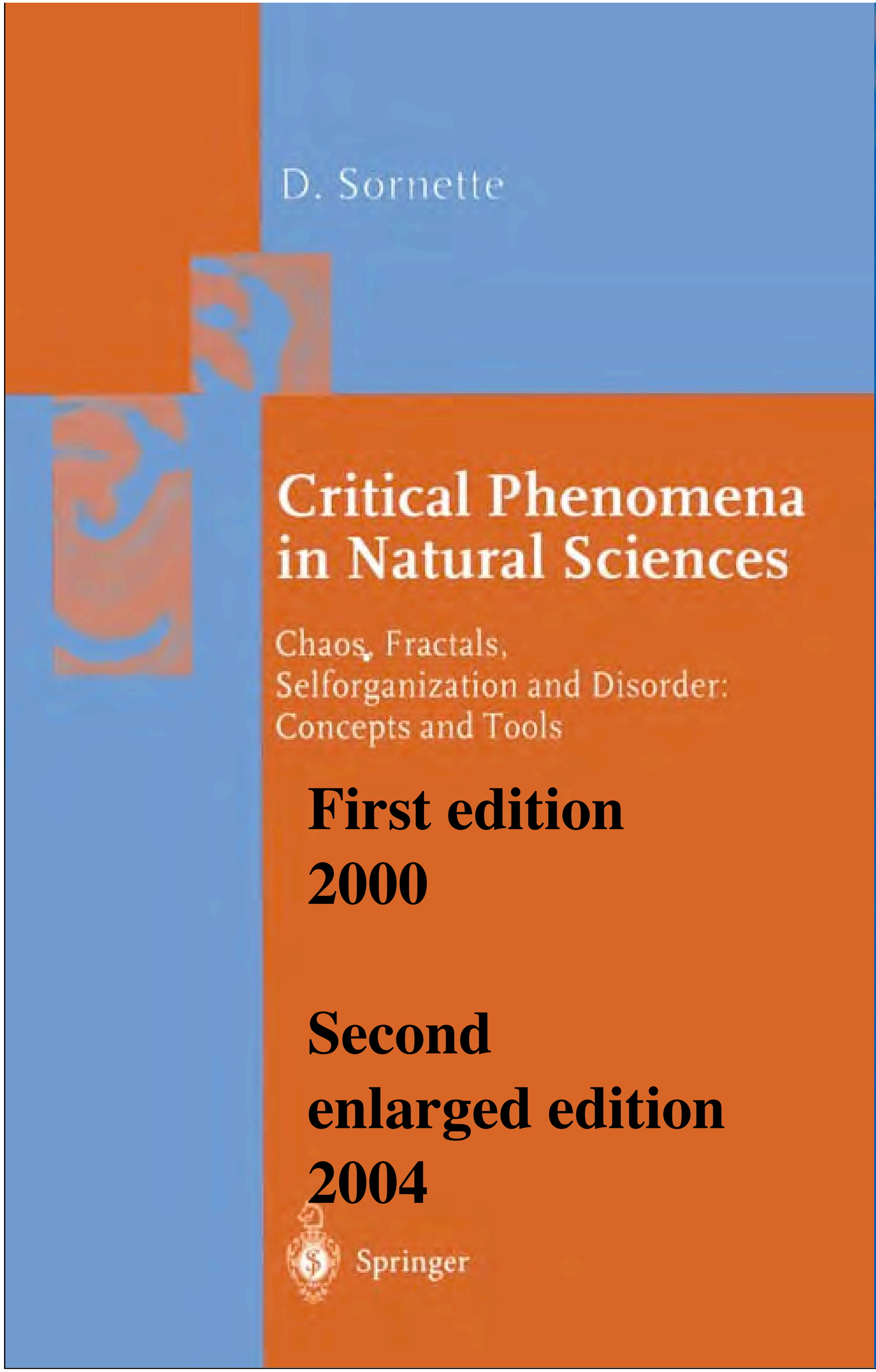
co-founder of the Competence Center for Coping with Crises in Socio-Economic Systems, ETH Zurich (http://www.ccss.ethz.ch/)

Department of Physics, ETH Zurich, Switzerland

Department of Earth Sciences ETH Zurich, Switzerland

Institute of Geophysics and Planetary Physics and Department of Earth and Planetary Sciences, UCLA, California.





First edition 2000

Second enlarged edition 2004