# Dynamical Diagnosis and Solutions for Resilient Natural and Social Systems

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The European Physical Journal

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EPJ ST

Recognized by European Physical Society

Special Topics

Dragon-kings

D. Sornette, and G. Ouillon
From Black Swans to Dragon Kings.
Is There Life Beyond Power Laws?
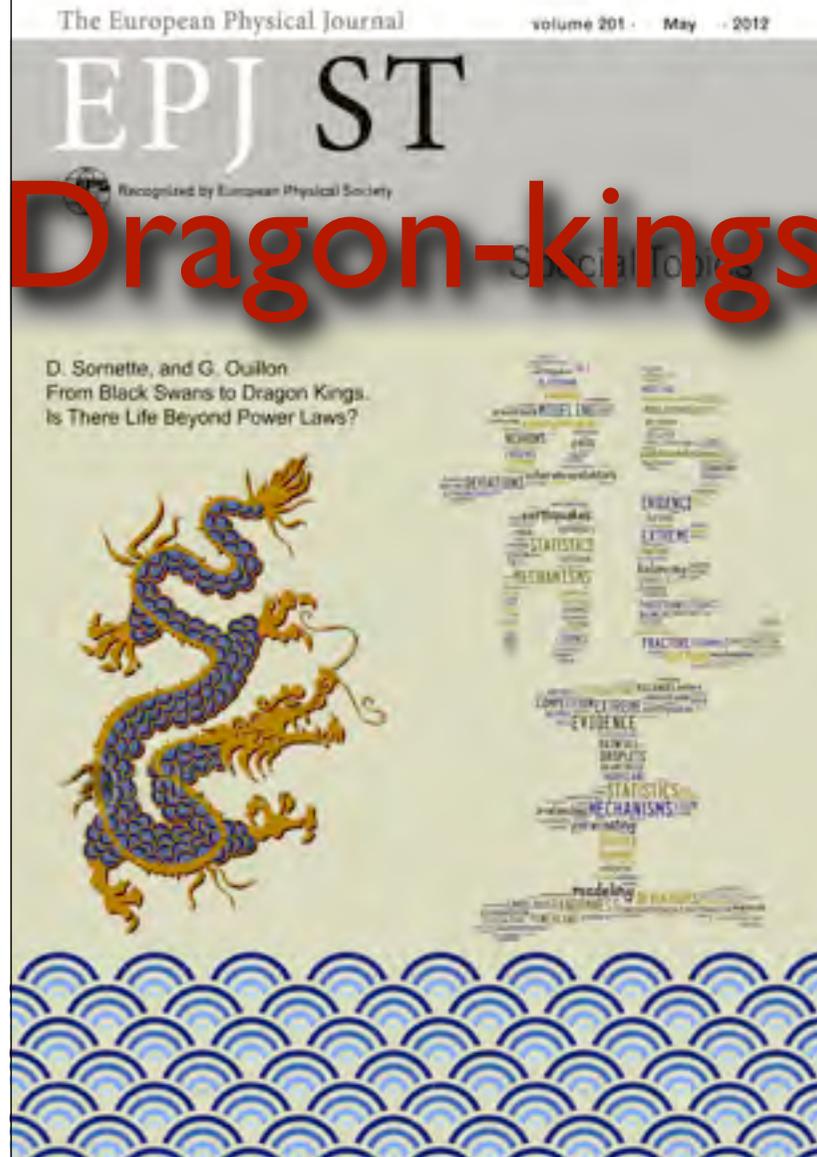
Didier Sornette

(with P. Cauwels, V. Filimonov, A. Saichev and R. Woodard, W.-X. Zhou)

Professor of Entrepreneurial Risks at ETH Zurich

Professor of Finance at the Swiss Finance Institute

Director of the Financial Crisis Observatory

Founding member of the Risk Center at ETH Zurich (June 2011) (www.riskcenter.ethz.ch)

Professor of Geophysics associated with the Department of Earth Sciences (D-ERWD), ETH Zurich

Professor of Physics associated with the Department of Physics (D-PHYS), ETH Zurich

www.er.ethz.ch

Big problems are piling up...

The "problem" of the post-financial crisis

Implosion of major banks
### (bank market value)

Morgan Stanley — 49 / 21

RBS — 120 / 22

Deutsche Bank — 76 / 26

Credit Agricole — 67 / 30

Societe Generale — 80 / 33

Barclays — 91 / 35

Unicredit — 93 / 41

UBS — 116 / 46

Credit Suisse — 75 / 49

Goldman Sachs — 100 / 56

BNP Paribas — 108 / 64

Santander — 116 / 80

Citigroup — 255 / 82

JPMorgan — 165 / 147

HSBC — 215 / 169
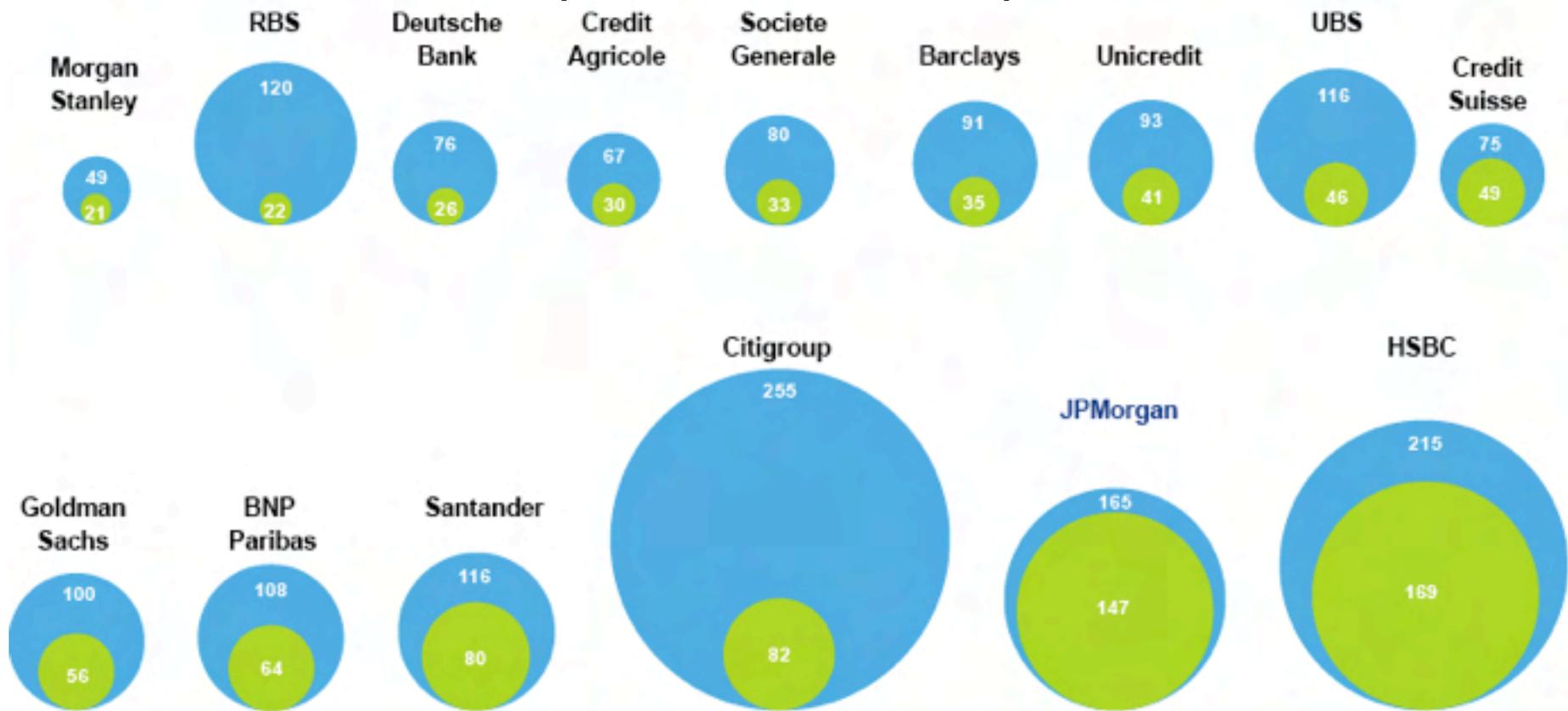
Q2 2007   to   20 Oct. 2008

The "problem" of the post-financial crisis

Central Bank Balance Sheets
(China, ECB, U.S. and Japan)

The Size Of The Eight Central Bank Balance Sheets
As A Percent Of World Market Capitalization

PBoC - Chinese Central Bank Balance Sheet (Converted To Dollars)

The ECB Balance Sheet (Converted to Dollars)

The Federal Reserve Balance Sheet

BoJ Balance Sheet (Converted To Dollars)
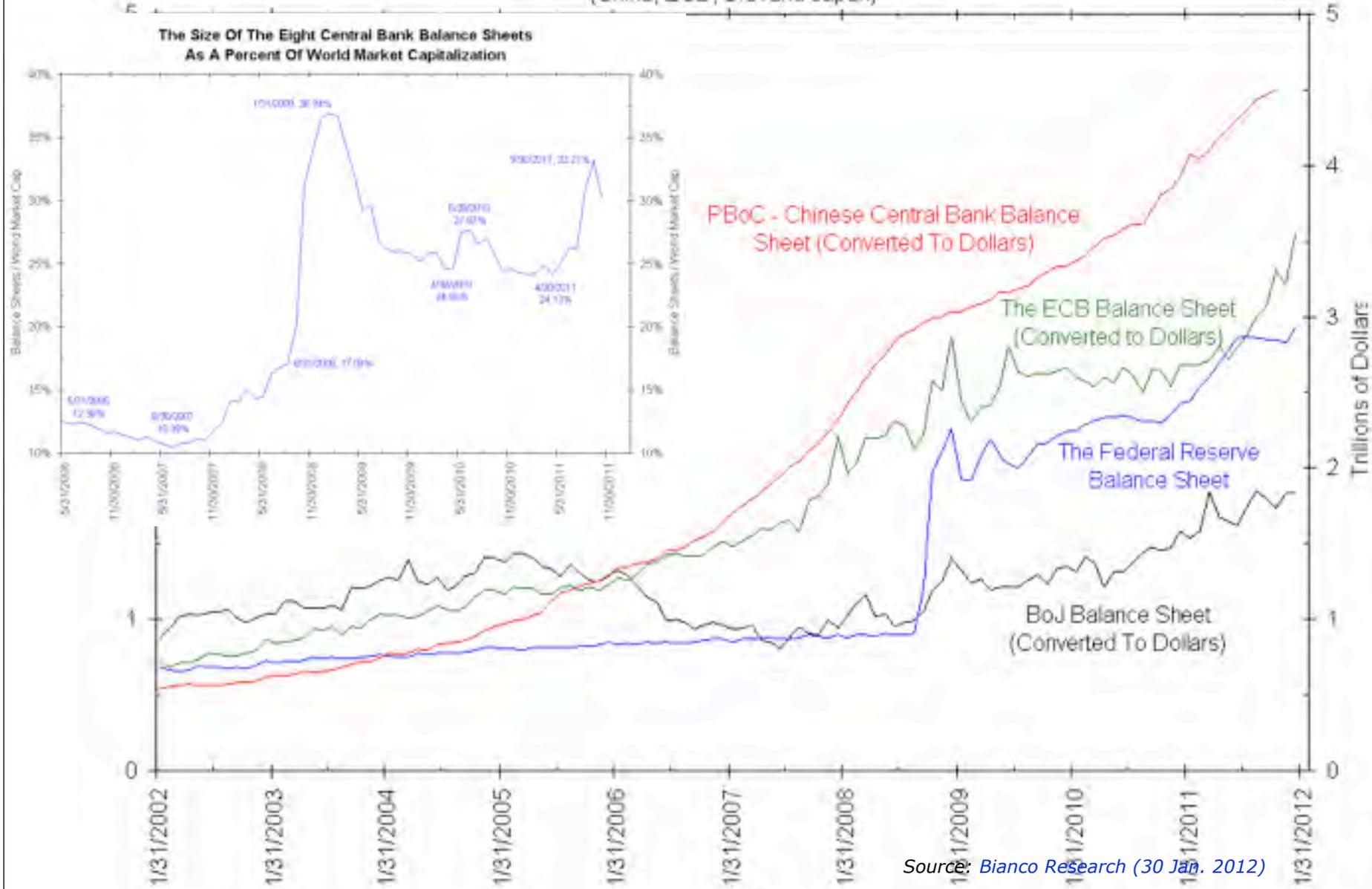
Source: Bianco Research (30 Jan. 2012)

The "problem" of the post-financial crisis

Derivatives, notional amounts outstanding, $trn

- Exchange-traded options
- Exchange-traded futures
- Foreign exchange ⎱
- Interest rate ⎰ OTC†
- CDS* ⎱
- Other OTC ⎰

800
600
400
200
0

1998   2000   02   04   06   08   10   11
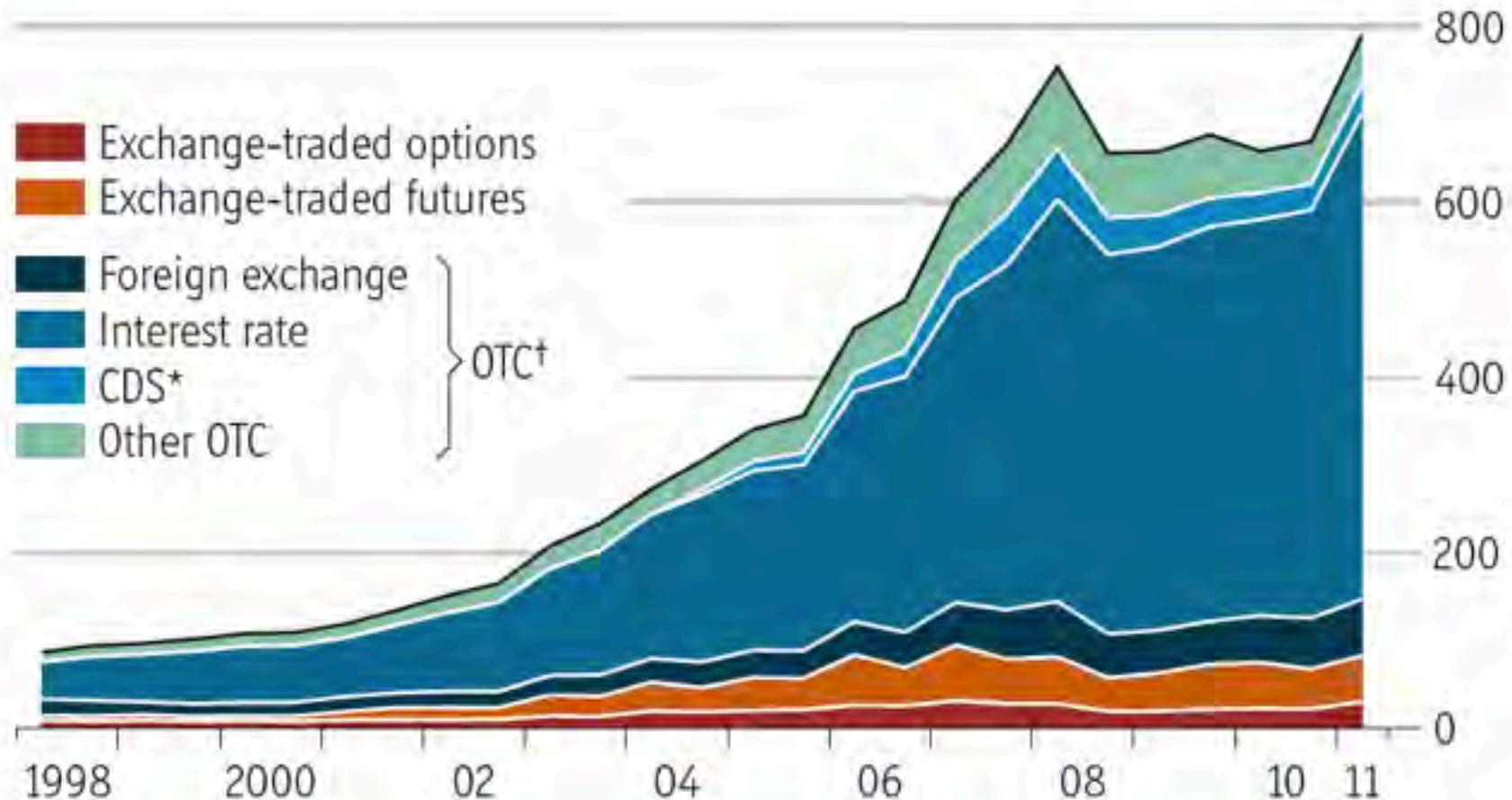
Source: Bank for International Settlements   *Credit-default swap   †Over the counter

The "problem" of sovereign debts
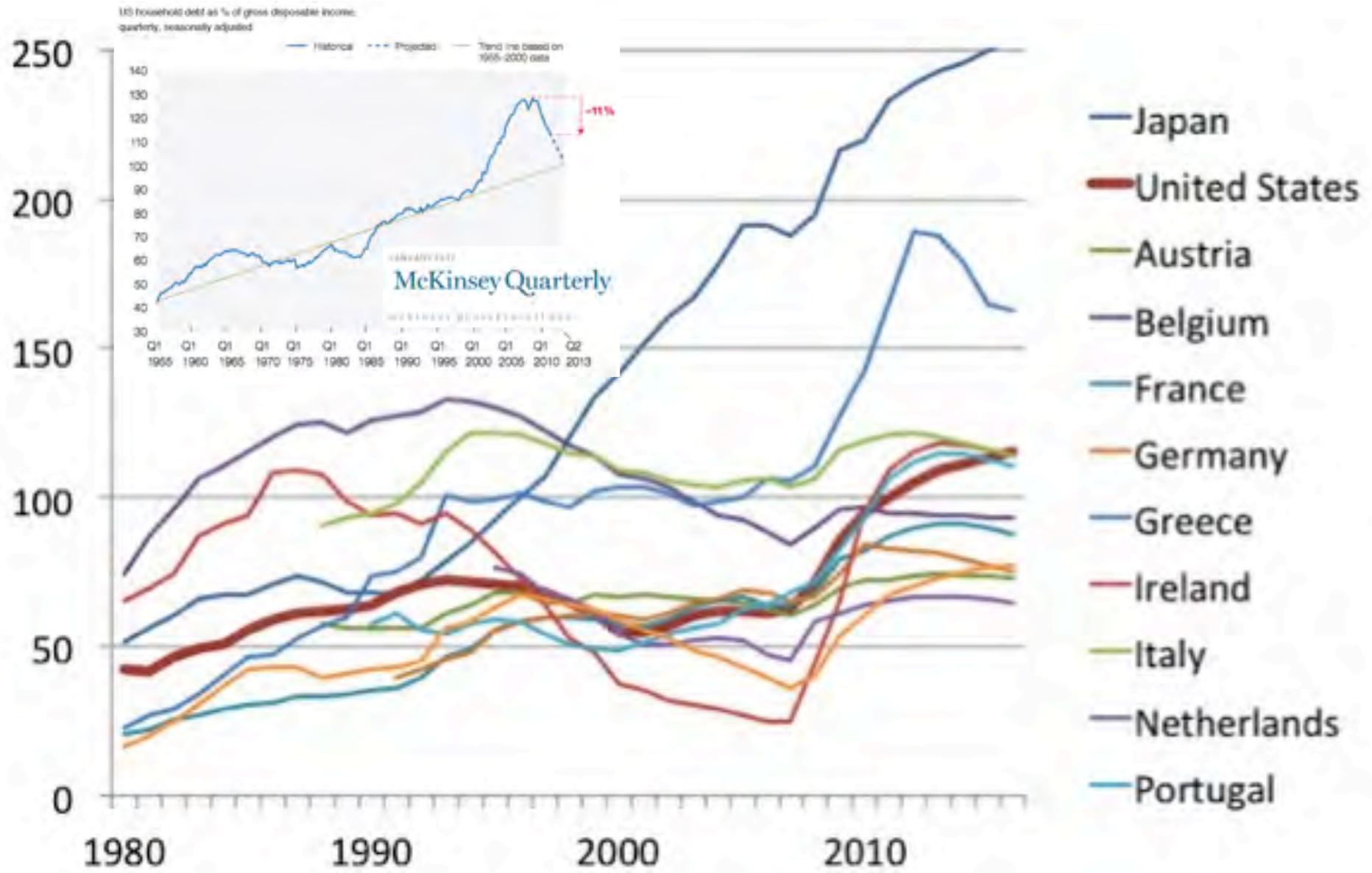

Gross debt to GDP, 1980-2016 (Niall Ferguson, 2012)

The faces of malnutrition

The "problem" of the "epidemics" of obesity and chronic diseases

The natural history of childhood overweight/ obesity using IOTF cut-offs in Australia over the last century and regional global increases


Australia

% overweight + obese

Raw data

All data

Year
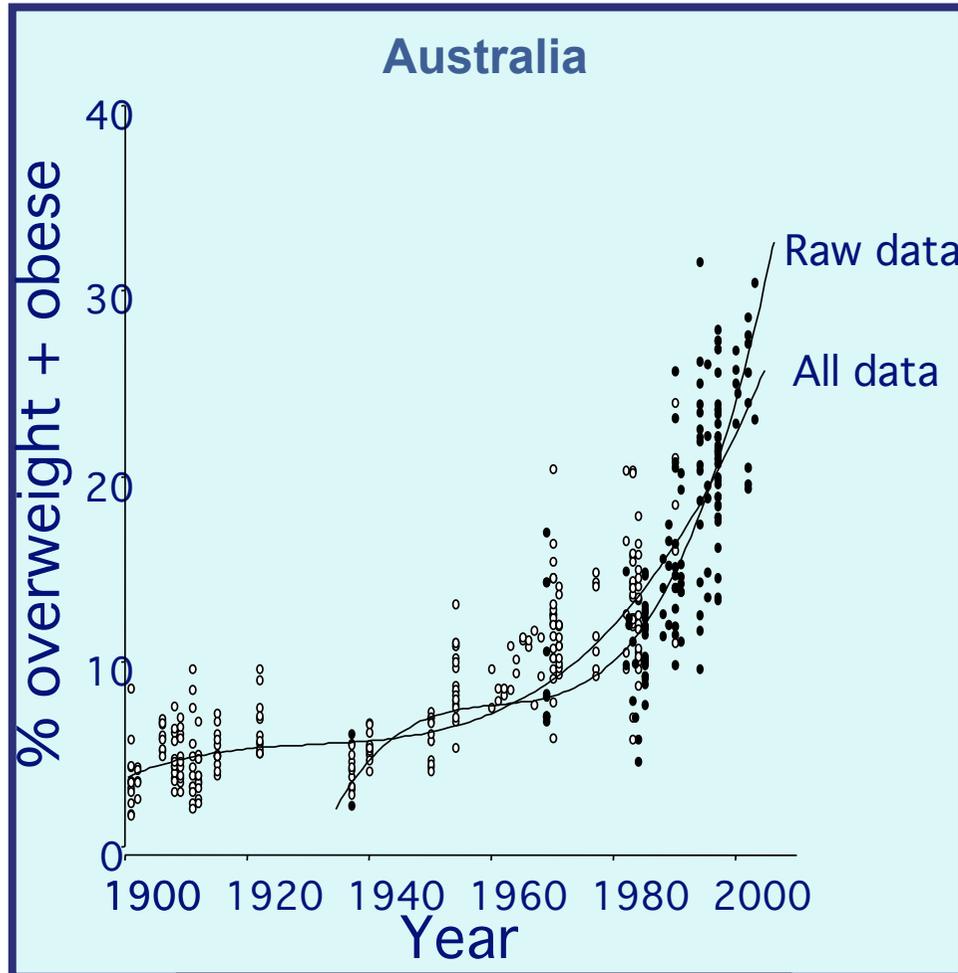
Norton K et al, Int J Ped Ob 2006

%

50.0

37.5

25.0

12.5

0

e.g. US

e.g. S.Arabia

e.g. UK

e.g.

e.g.

- Americas (1988-2002)
- Eastern Med (1992-2001)
- Europe (1992-2003)
- South East Asia (1997-20
- West Pacific (1993-2000)
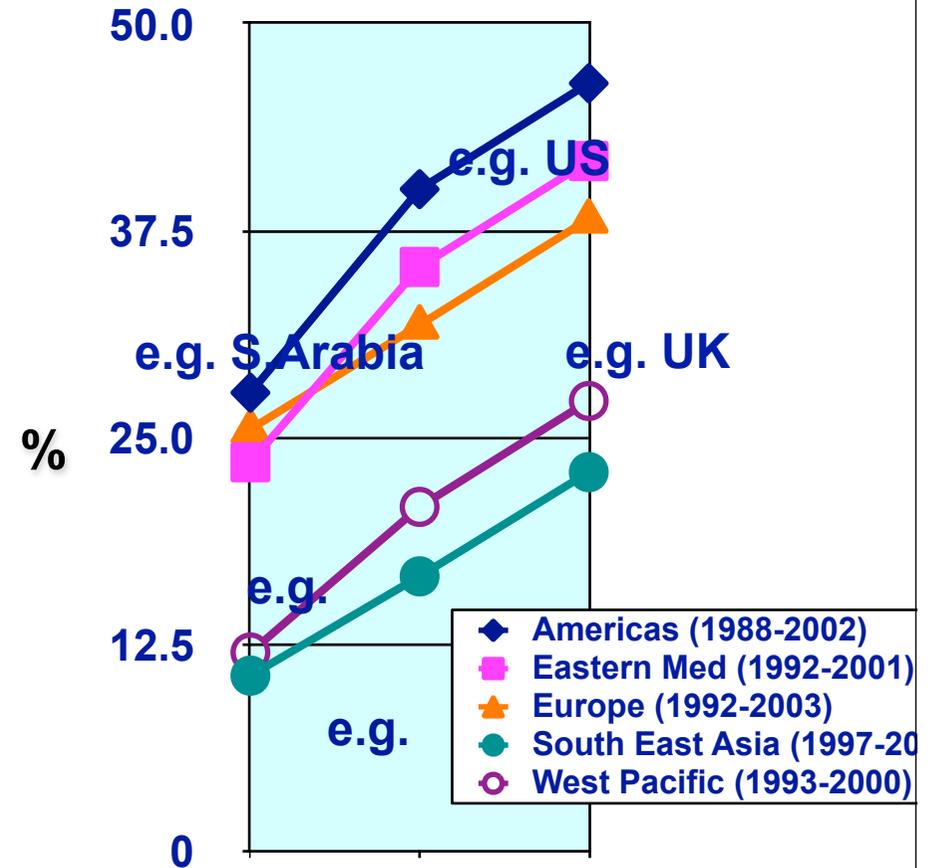
Global total now: obese 74 mil. +overwt. 287 mil.

Wang and Lobstein, IOTF, Int J Ped Ob 2006.

(Philip James, 2010)

The "problem" of aging

UN forecasts: percentage people over 60 years

Jean Laherrere Feb.2003

Legend:
- Sub-Sah. Africa
- Middle East
- North Africa
- South Asia
- Latin America
- World
- World P10
- World P90
- China region
- North America
- Eastern Europe
- Western Europe
- Pacfic OECD
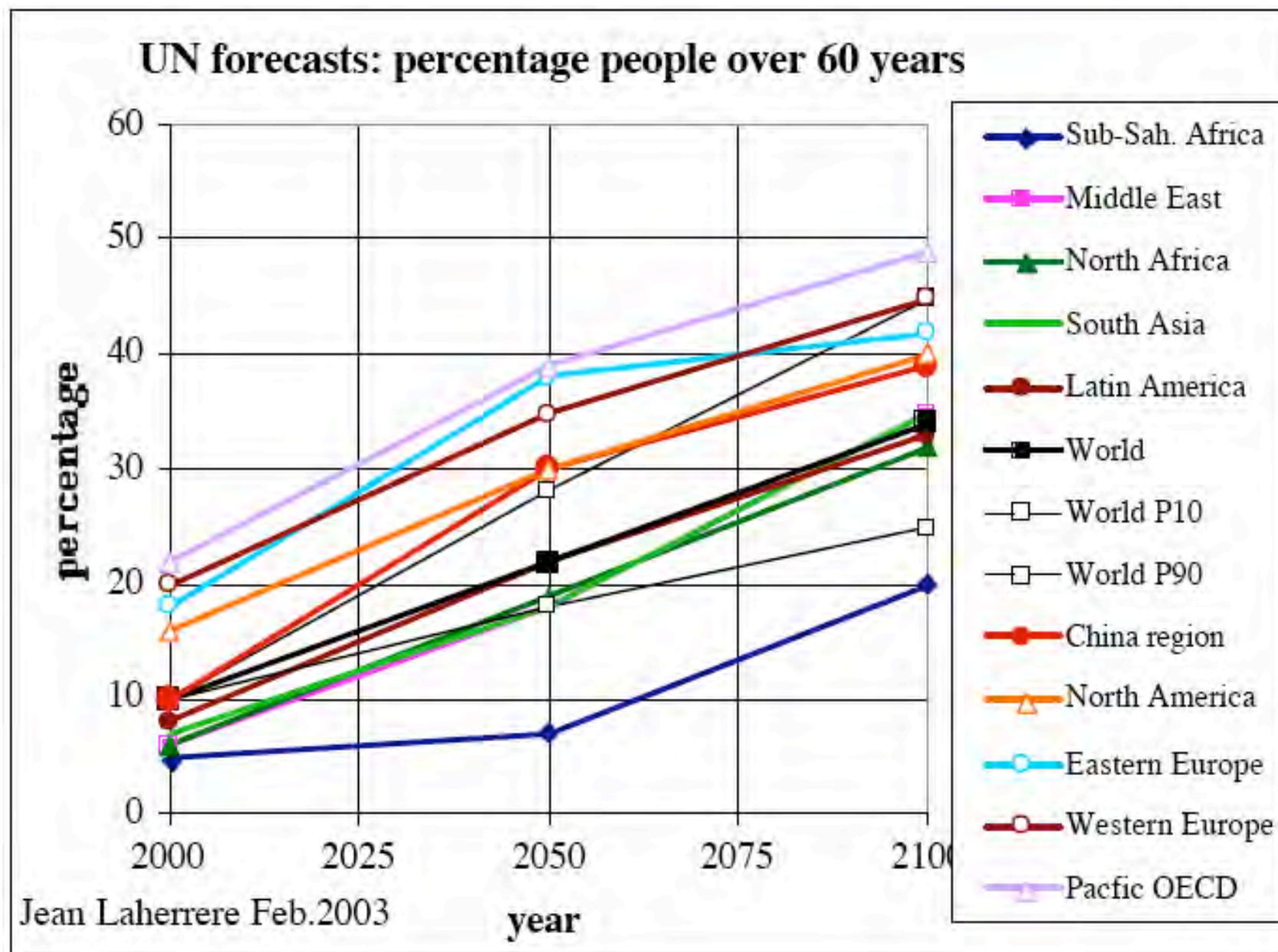
The energy problem

•Econometric analysis of growth in the USA, Japan, and Germany between 1960 and 1996 shows that **energy drives about 50% of economic growth**.

•Mainstream economics, on the other hand, gives energy only a weight of 5% according to energy's share in the total cost of the production factors capital, labor and energy.

(1) Ch. Hall, D. Lindenberger, R. Kummel, T. Kroeger, and W. Eichhorn, The need to reintegrate the natural sciences with economics" Bio-Science 51, 663-673 (2001).
(2) R. U. Ayres and B. Warr, Accounting for growth: the role of physical work", (2001). R. U. Ayres, L. W. Ayres and B. Warr, Exergy, Power and Work in the US economy, 1900 - 1998   (2001)

World energy consumption

World primary energy growth versus consumption from BP data 1965-2001

Jean Laherrere
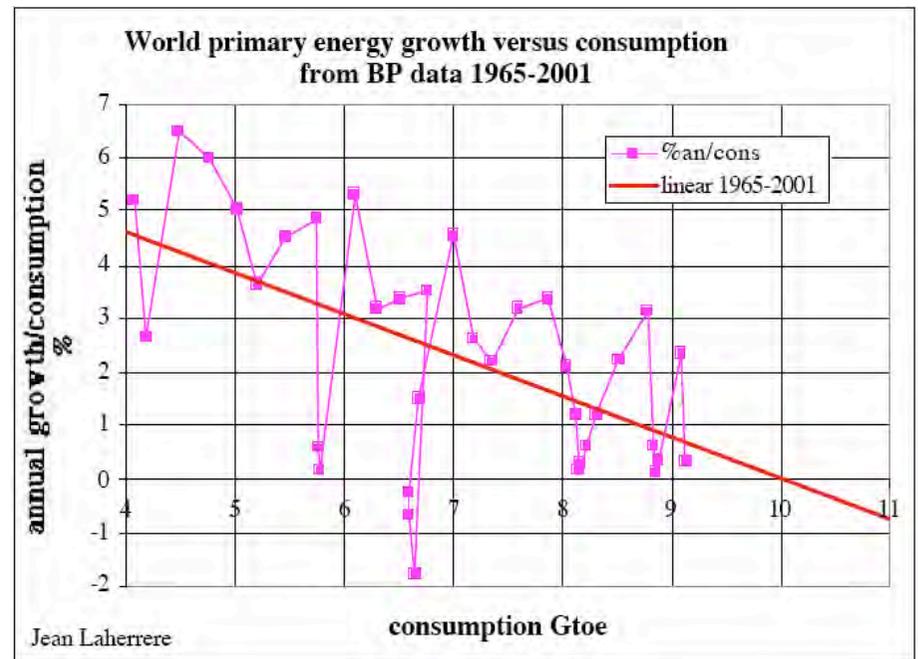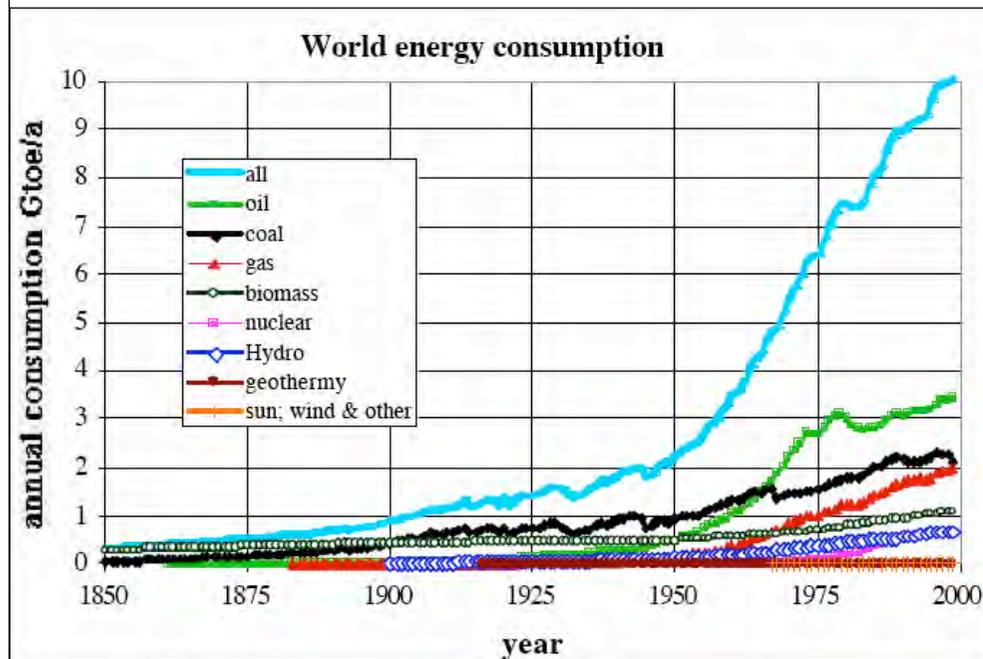
The water problem
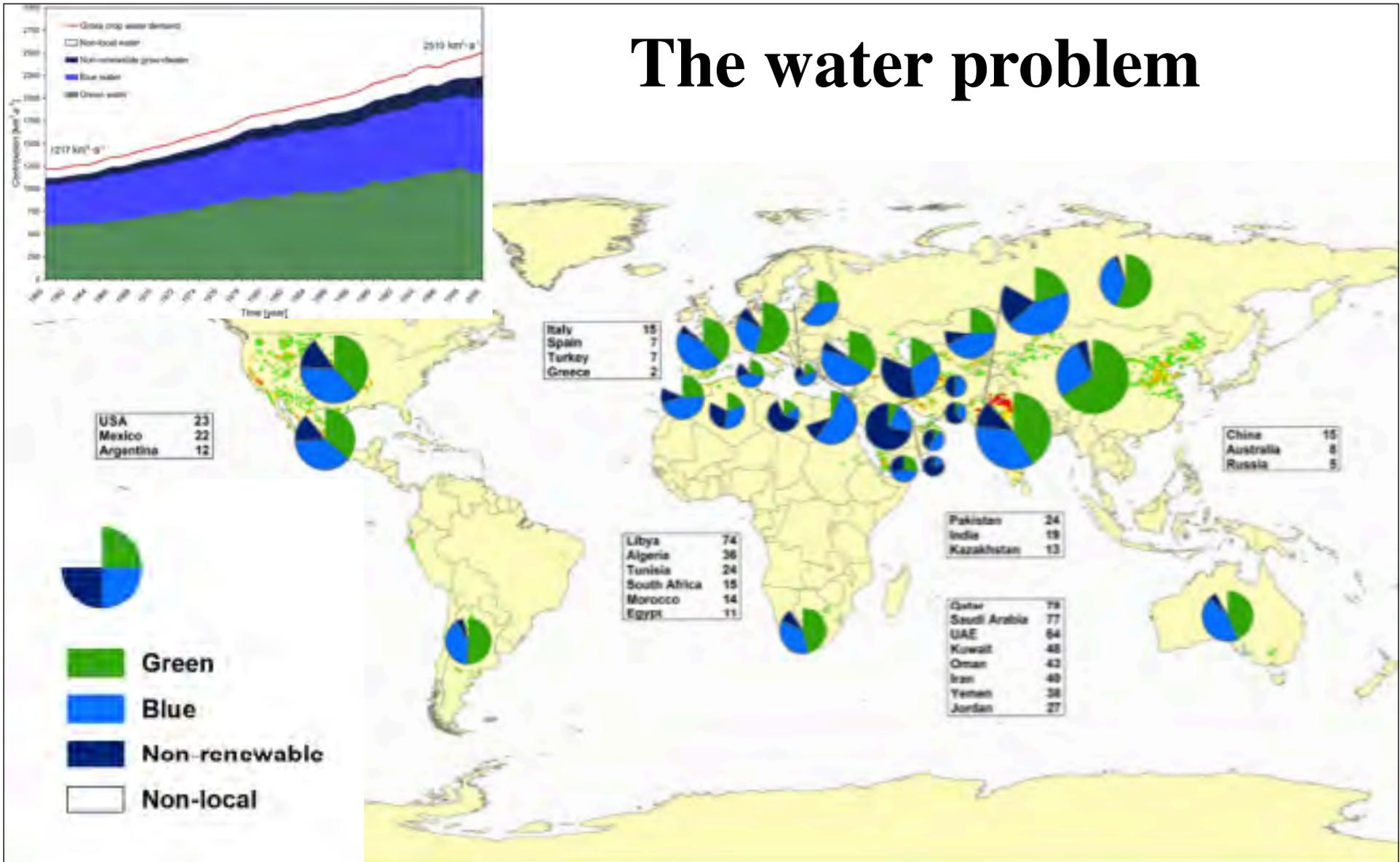
Current contribution per water resource to water used for irrigated crops (gross crop water demand in irrigated areas) for major groundwater users. Background shows a map of nonrenewable groundwater abstraction for irrigation. Labels indicate percentages of nonrenewable groundwater abstraction contributing to gross irrigation water demand (%). Sizes of pie charts are relative to amounts of gross crop water demand in irrigated areas among the countries shown.

Wada, Y., L. P. H. van Beek, and M. F. P. Bierkens (2012), Nonsustainable groundwater sustaining irrigation: A global assessment, Water Resour. Res., 48, W00L06, doi:10.1029/2011WR010562

The "problem" of soil erosion

Figure 1. About 50 mm of soil blown from cropland in Kansas during the winter of 1995–1996 (E.L Skidmore, USDA, Manhattan, KS., photo spring of 1996).

David Pimentel
Environment, Development and Sustainability (2006) 8: 119–137
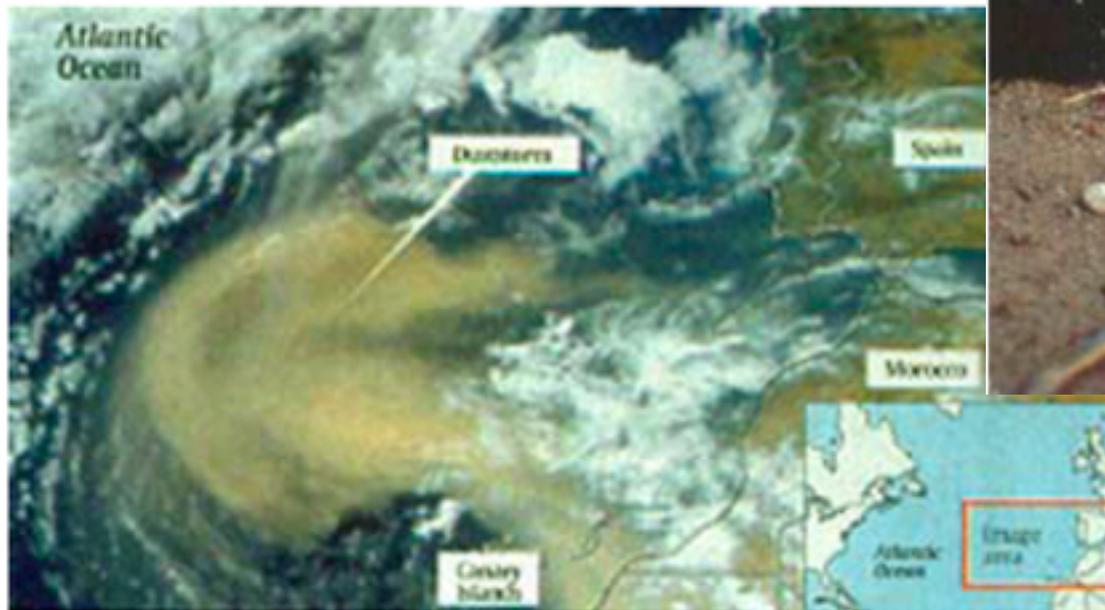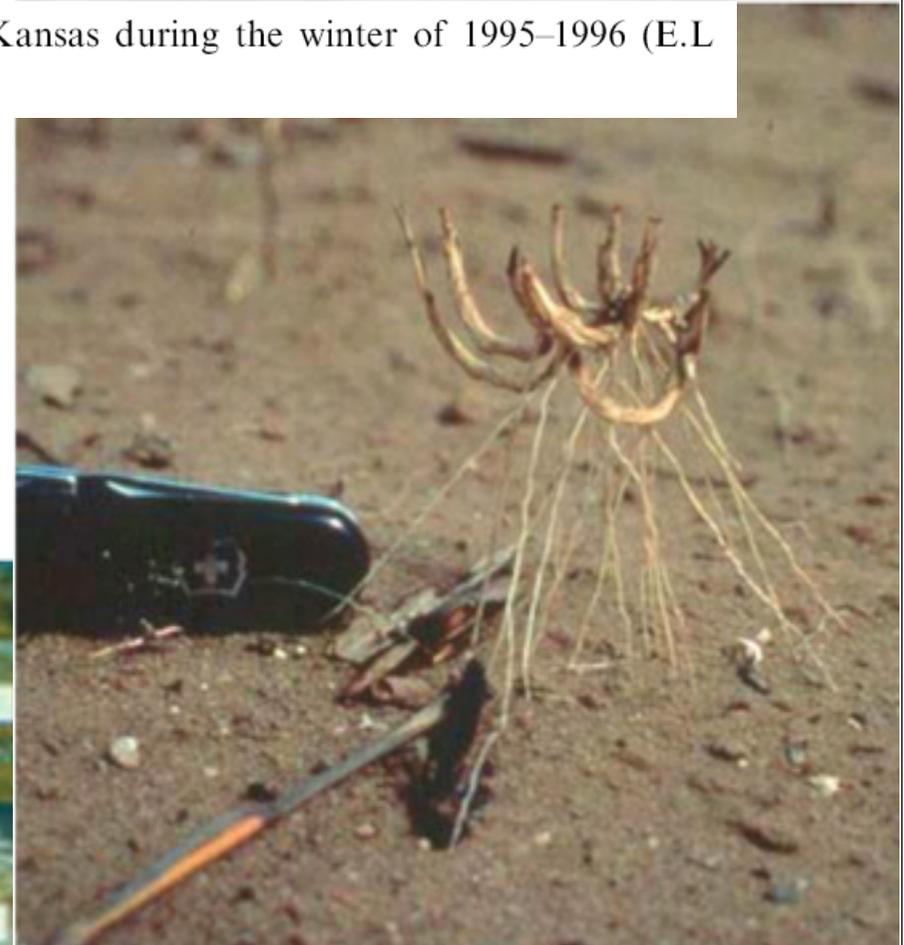
Figure 2. Cloud of soil from Africa being blown across the Atlantic Ocean (Imagery by SeaWIFS Project, NASA/Goddard Space Flight Center and ORBIMAGE, 2000).

Humanity in the Anthropocene
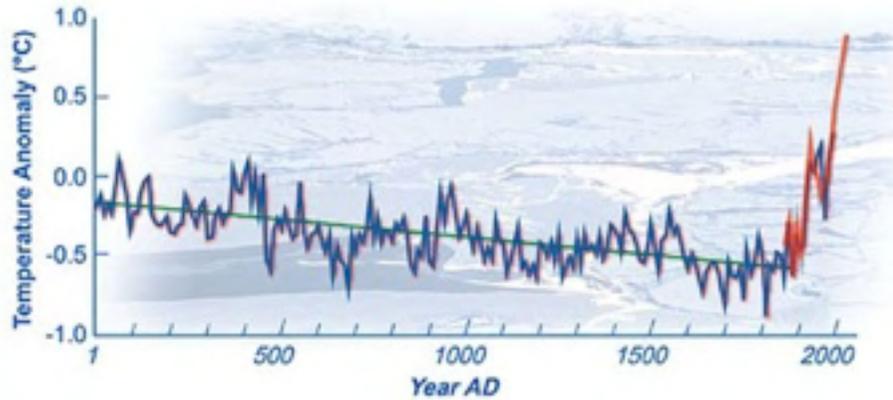
Kaufman, Darrell S., et al. 2009. Recent Warming Reverses Long-Term Arctic Cooling. *Science*, September 4, 2009

Lee R. Kump   SCIENCE VOL 323 27 FEBRUARY 2009

Johan Rockström (Stockholm Resilience Centre)
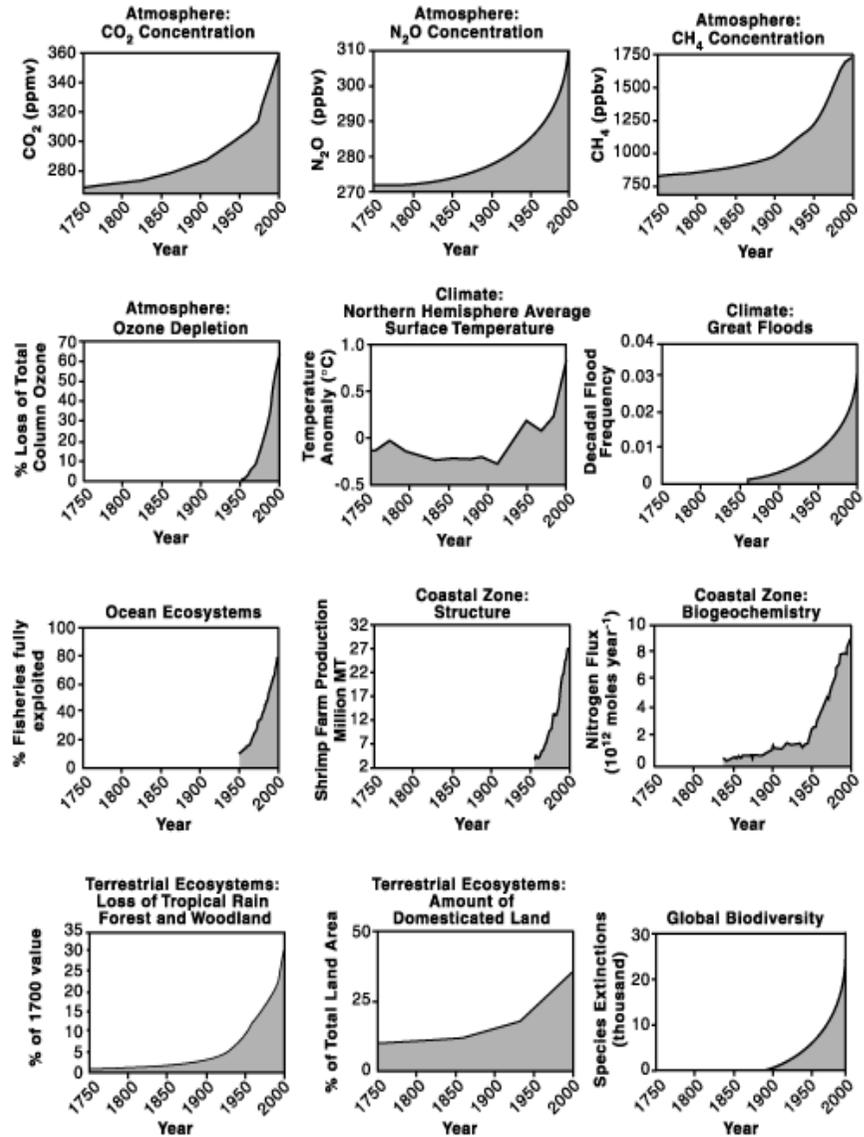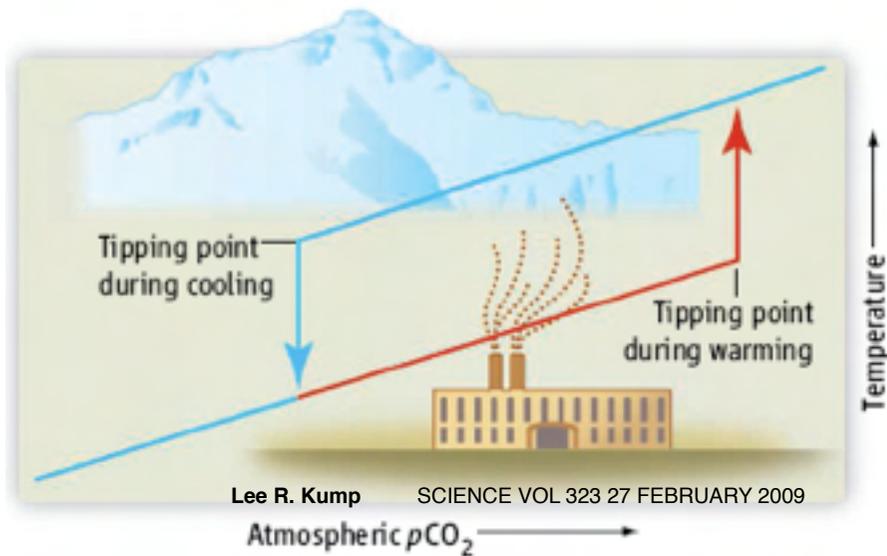

Steffen, W., et al. 2004

The "problem" of the 6th global biological extinction

Species are becoming extinct at a rate of:
~ 4,000 – 30,000 species/year
~100/day
~1 species every 15 minutes
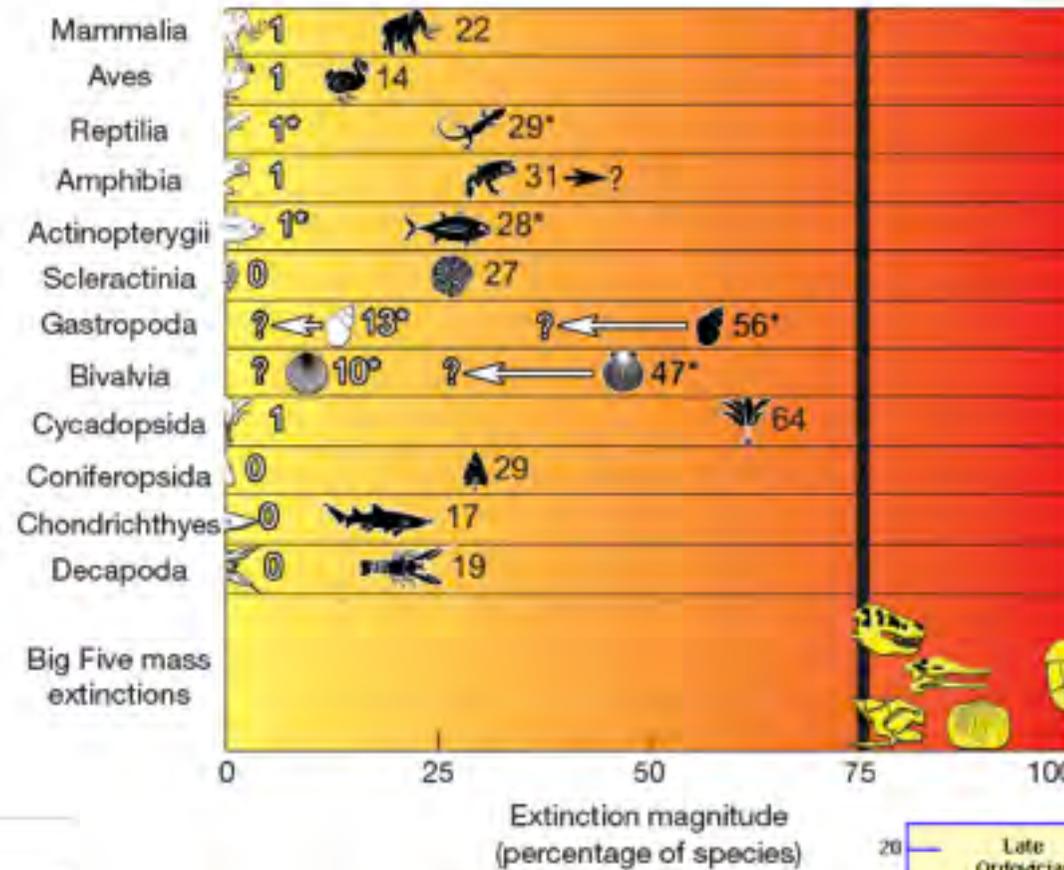
Extinction magnitudes of IUCN-assessed taxa in comparison to the 75% mass-extinction benchmark (International Union for Conservation of Nature)

Barnosky et al., Nature 471, 51-57 (2011)
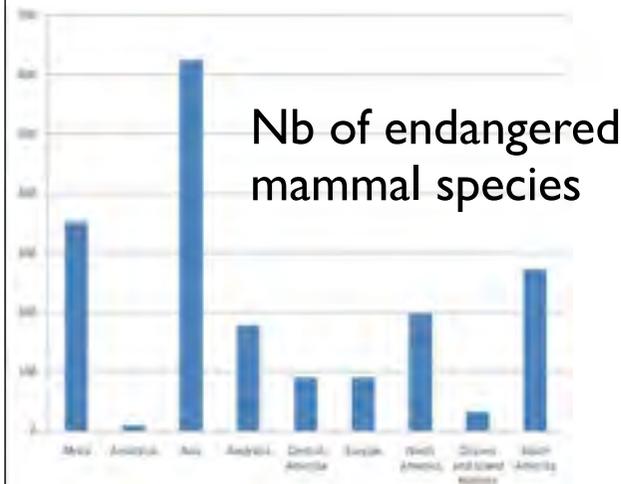
Nb of endangered mammal species

(B. Taylor, 2011)
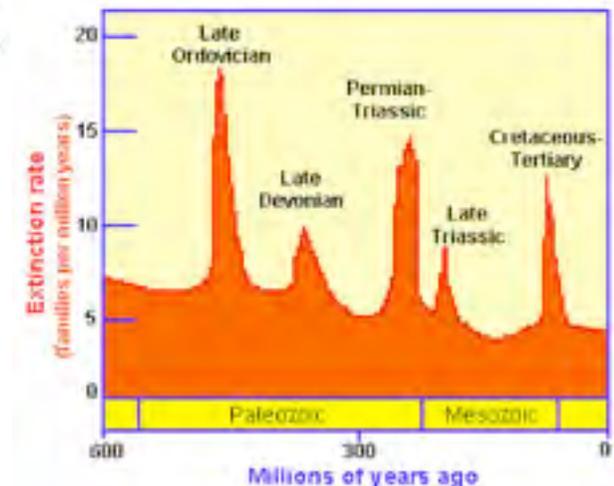
The "problem" of Earth boundaries

Climate Change

Ozone depletion

Phosphorus flow

Atmospheric aerosol load

Nitrogen flow

Ocean acidity

Biodiversity loss

Freshwater consumption

Agricultural land use

Chemical pollution

Latest data

90-00

70-80

50-60

Pre-Ind.

Prof. Johan Rockström
Stockholm Resilience Centre
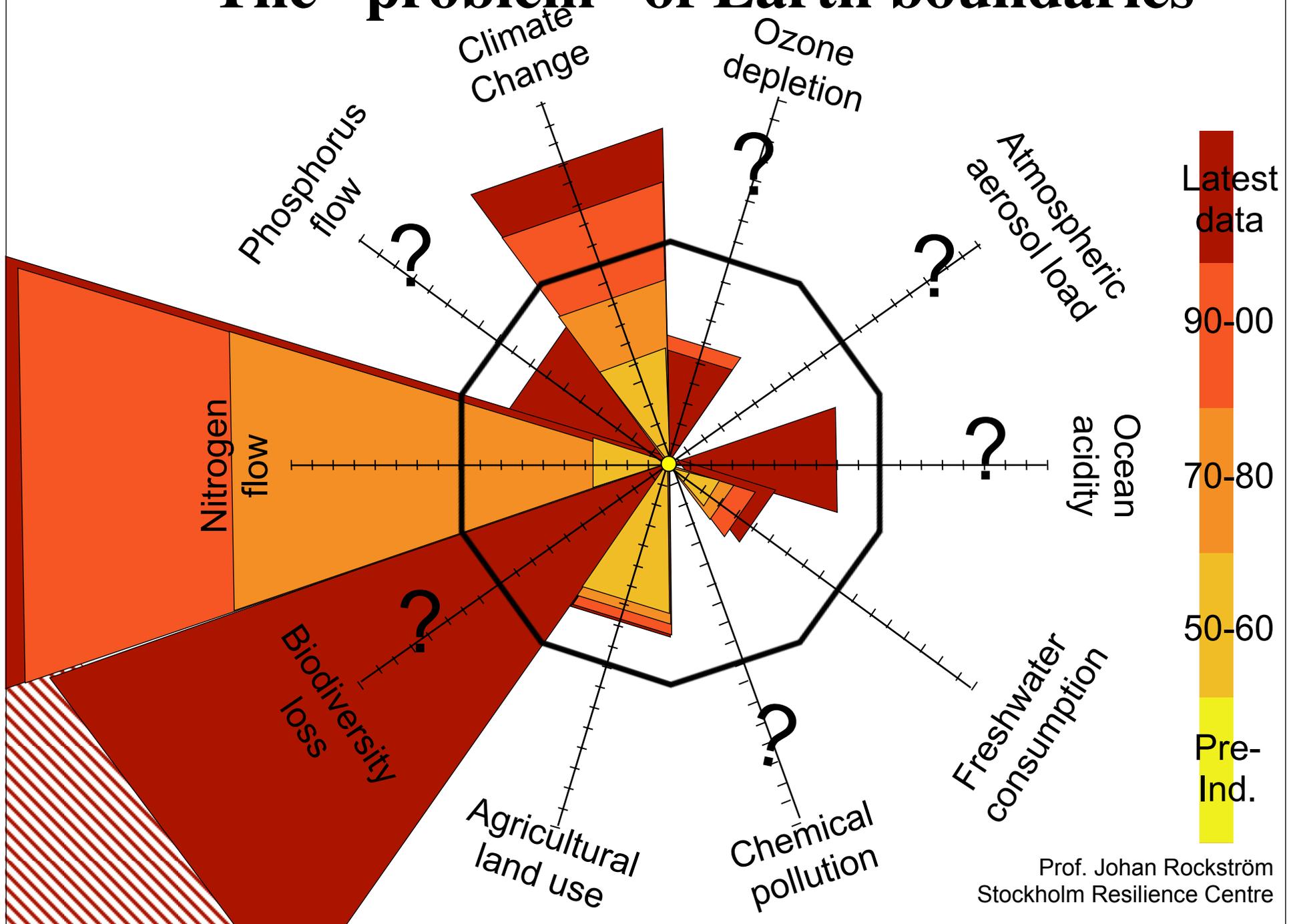
The "problem" of consuming 1.5 Earth's

Biodiversity, biocapacity and development
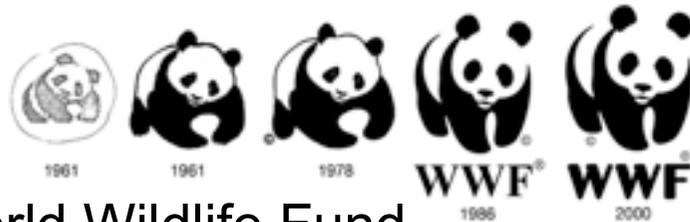
World Wildlife Fund
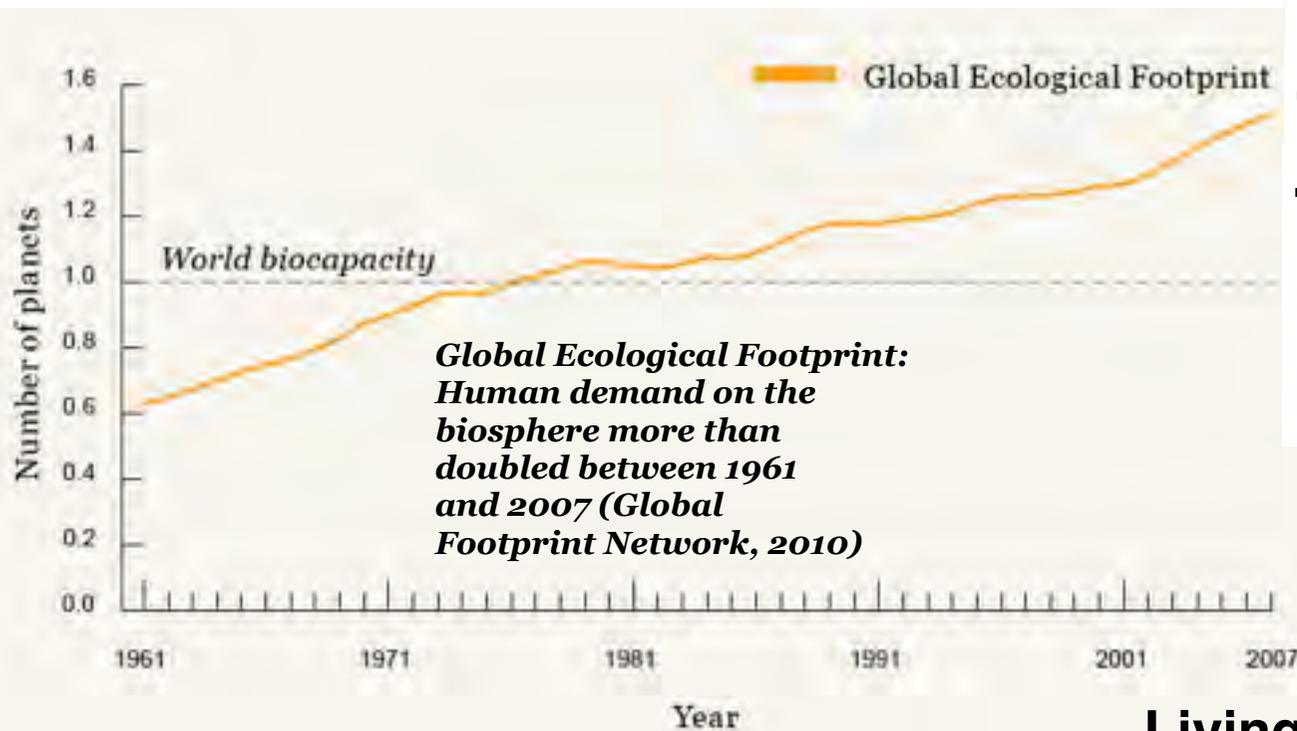
carbon
grazing
forest
fishing
cropland
build-up land

Global Ecological Footprint

World biocapacity

Global Ecological Footprint: Human demand on the biosphere more than doubled between 1961 and 2007 (Global Footprint Network, 2010)

Number of planets

Year

Living Planet Report 2010

The "problem" of extreme industrial disasters

Deepwater Horizon oil spill
(April 2010)

Fukushima-Daiichi
(11 March 2011)
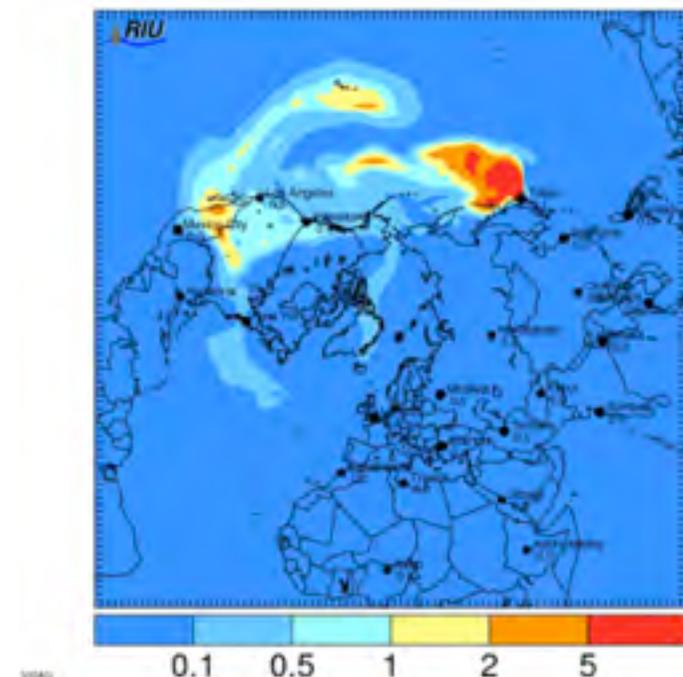
The "problem" of geo-political risks

2012 Political Risk Map — Oxford Analytica

The "problem" of ensuring social stability for responsible steering of sensitive industries and wastes (nuclear wastes, heavy metals, ...)
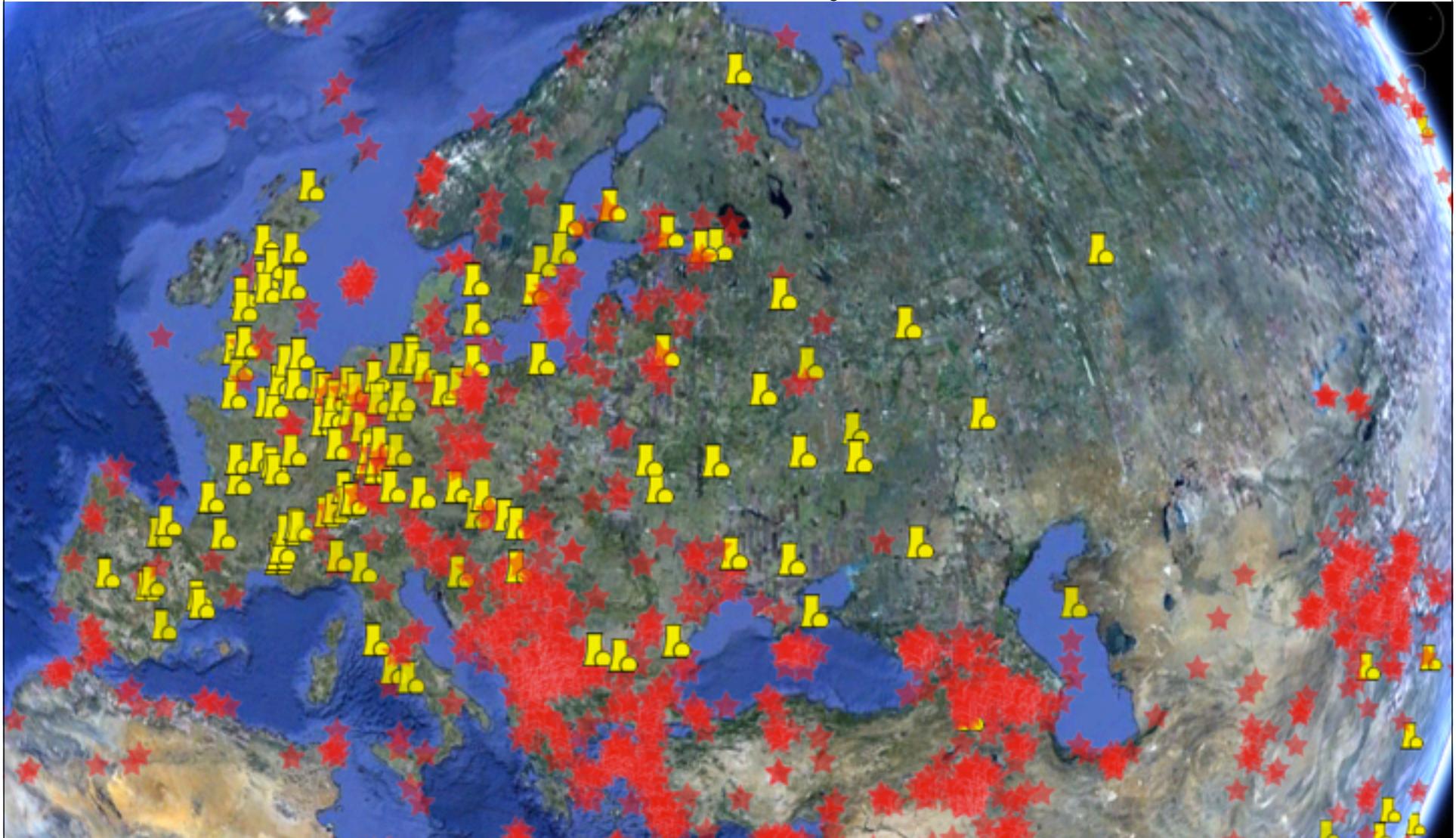
Approaching a state shift in Earth's biosphere and human systems

World human population
World GDP

Korotayev, Malkov
Khaltourina (2006)

GDP
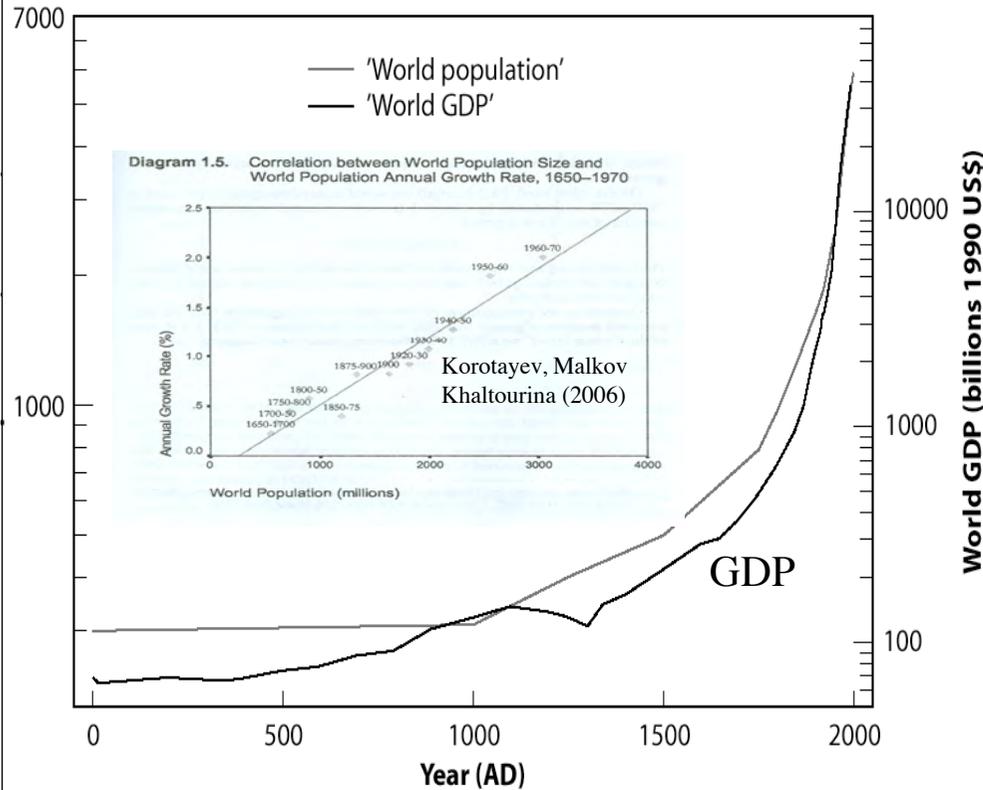
World financial markets
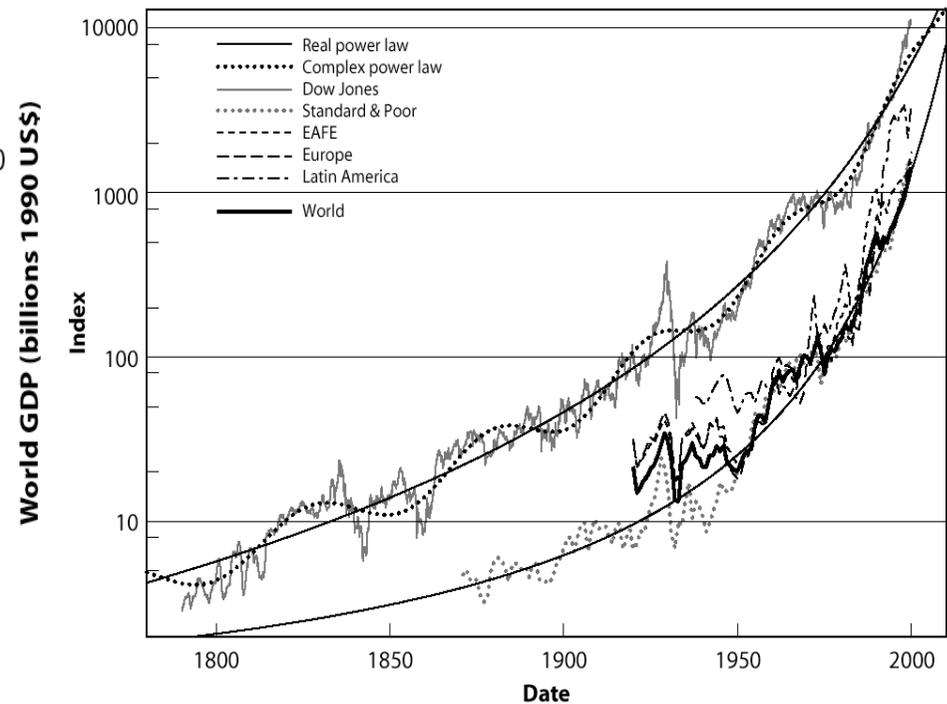
=> **regime shift in 2030-2060**
Has already started.

A. Johansen and D. Sornette
Finite-time singularity in the dynamics of the
world population and economic indices, Physica
A 294 (3-4), 465-502 (2001)

Approaching a state shift in Earth's biosphere
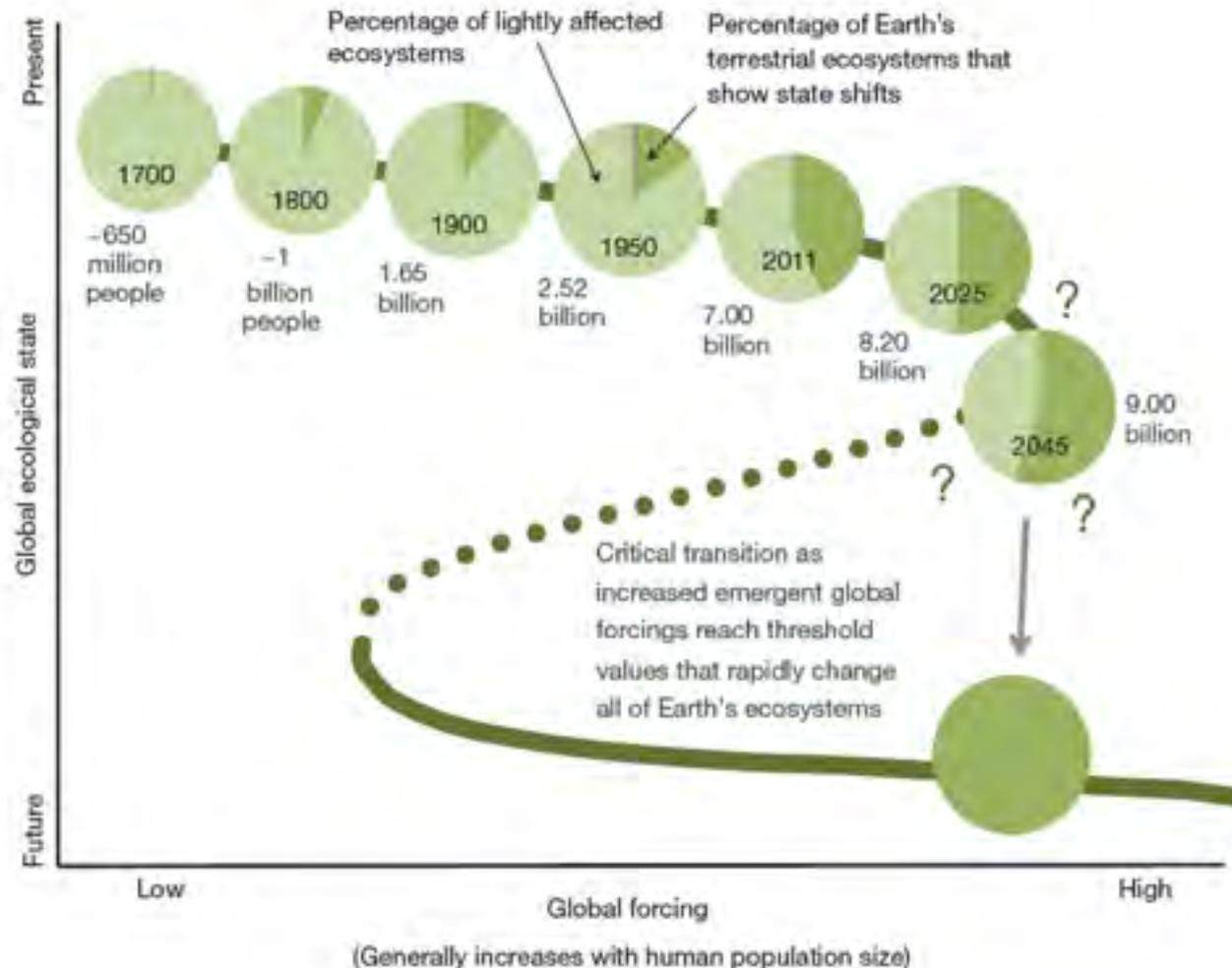
Barnosky et al.
Nature 486, 52-58
(2012)

Quantifying land use as one method of anticipating a planetary state shift. The trajectory of the green line represents a fold bifurcation with hysteresis[12]. At each timepoint, light green represents the fraction of Earth's land that probably has dynamics within the limits characteristic of the past 11,000 yr. Dark green indicates the fraction of terrestrial ecosystems that have unarguably undergone drastic state changes; these are minimum values because they count only agricultural and urban lands. The percentages of such transformed lands in 2011 come from refs 1, 34, 35, and when divided by 7,000,000,000 (the present global human population) yield a value of approximately 2.27 acres (0.92 ha) of transformed land for each person. That value was used to estimate the amount of transformed land that probably existed in the years 1800, 1900 and 1950, and which would exist in 2025 and 2045 assuming conservative population growth and that resource use does not become any more efficient. Population estimates are from refs 31–33. An estimate of 0.68 transformed acres (0.28 ha) per capita (approximately that for India today) was used for the year 1700, assuming a lesser effect on the global landscape before the industrial revolution. Question marks emphasize that at present we still do not know how much land would have to be directly transformed by humans before a planetary state shift was imminent, but landscape-scale studies and theory suggest that the critical threshold may lie between 50 and 90%(although it could be even lower owing to synergies between emergent global forcings). See the main text for further explanation.

Big problems are piling up...

Need for understanding their fundamental mechanisms...

to design robust strategies and solutions

Crises result from maturation towards an instability

Instead of Water Level:
-economic index (Dow-Jones etc…)

Dow Jones Industrials Weekly Chart

http://www.lowrisk.com

95 97 99 101

DJIA Weekly

1929 Crash

10/29

http://www.lowrisk.com

27   28   29   30
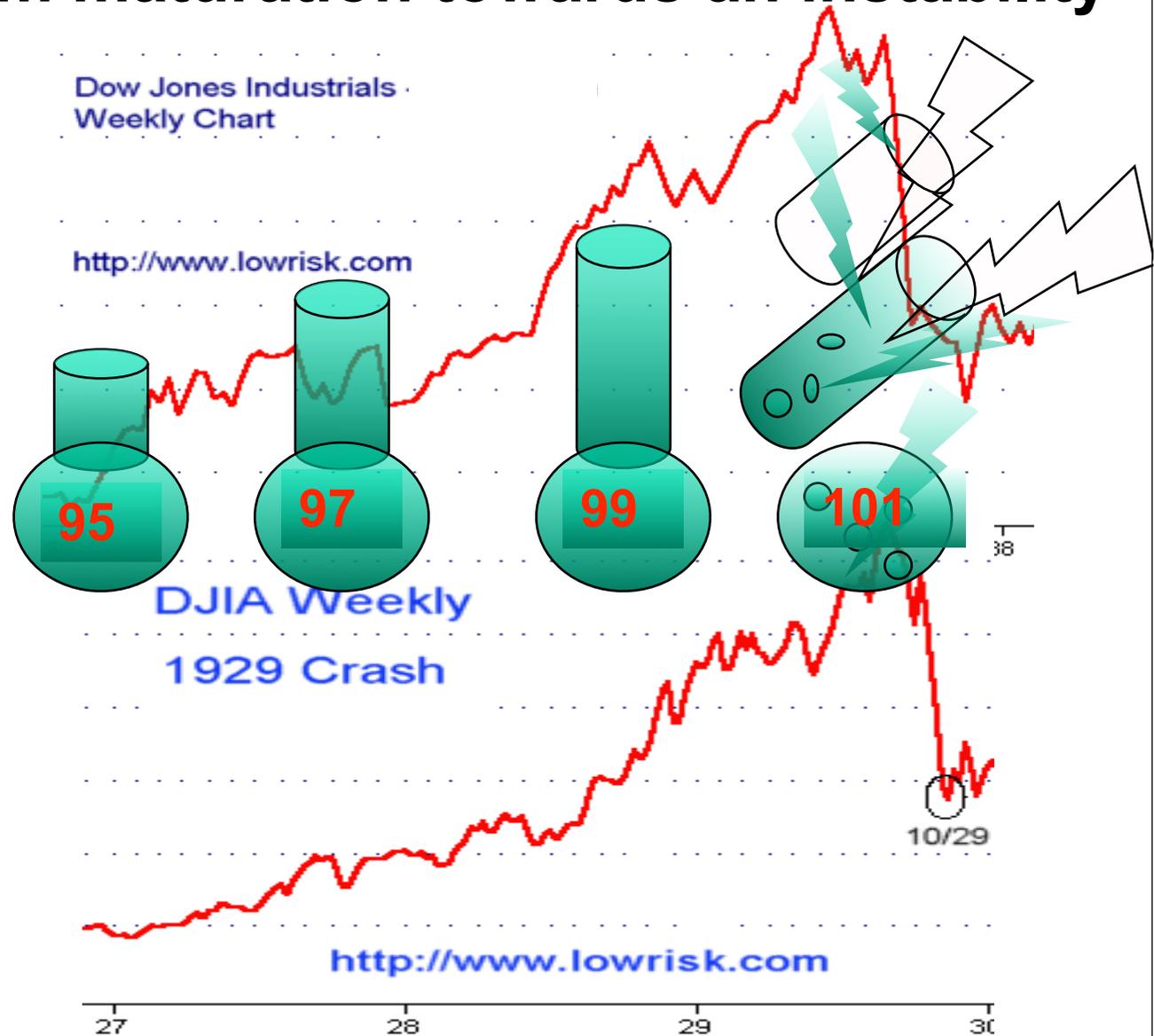
Crash = result of collective behavior of individual traders

(S. Solomon)

Critical Transitions

Peer pressure, leadership, complexity and homogeneity can influence critical transitions / shifts in group attitudes
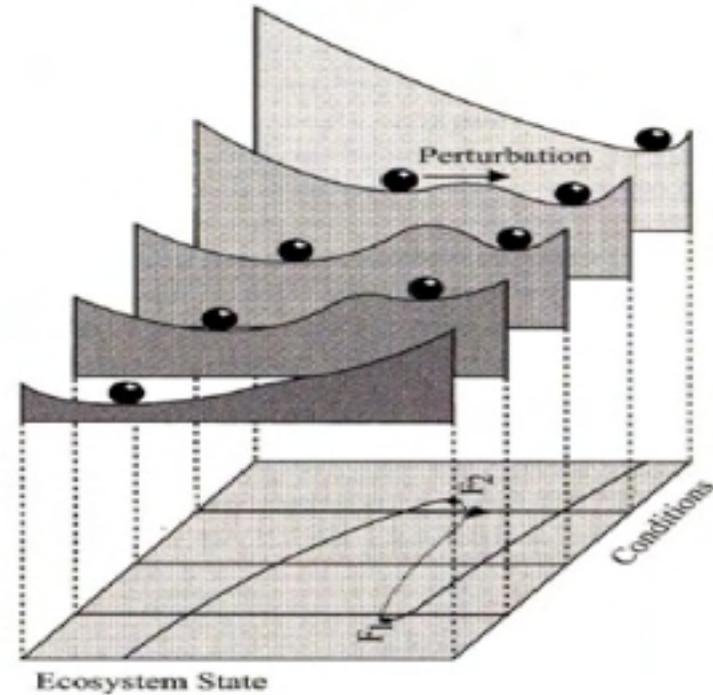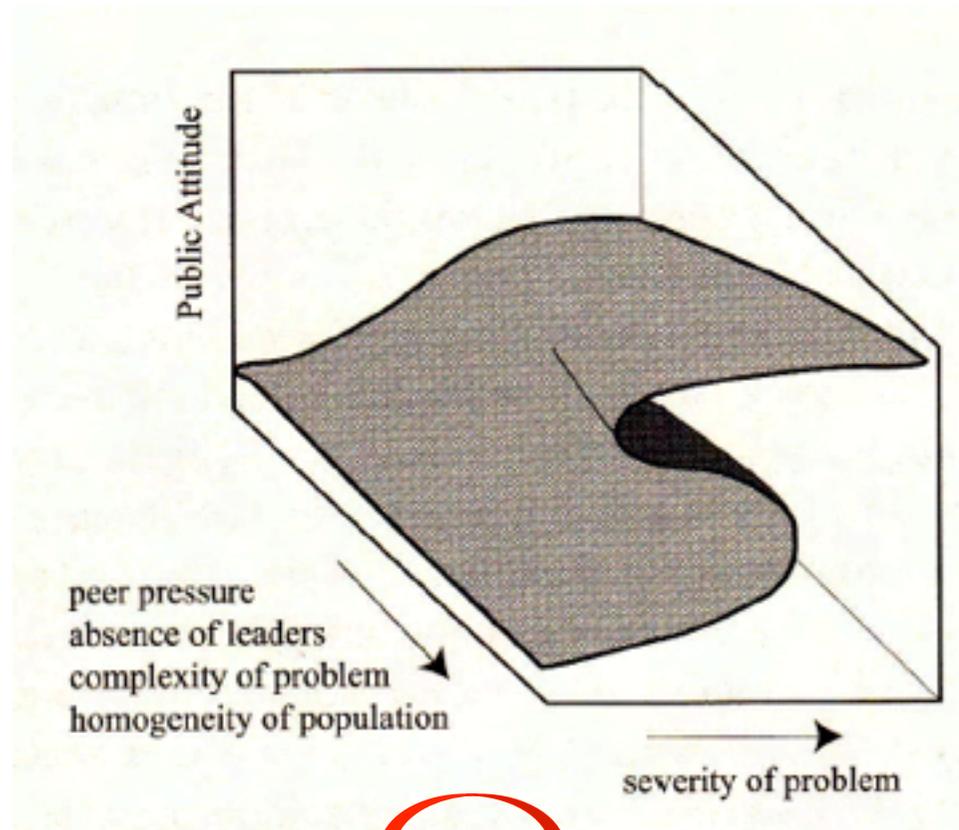
A **critical transition** occurs if external conditions transform the stability landscape.

In this figure, the system moves from an underexploited to an overexploited state. The initial global minimum is transformed in a local basin of attraction up to a point where a small perturbation shifts it into the newly global minimum state.

(M. Scheffer, 2009)

Fundamental reduction theorem

Generically, close to a regime transition, a system bifurcates through the variation of a SINGLE (or a few) effective "control" parameter

Bifurcation: Qualitative change in behavior
as parameter is (slowly) varied
Bifurcation surface: B

Strategy 1: understand from proximity to a reference point as a function of a small parameter

Strategy 2: a few universal "normal forms"

Space of all dynamical systems: $\mathcal{M}$
a particular dynamical system: $M \in \mathcal{M}$
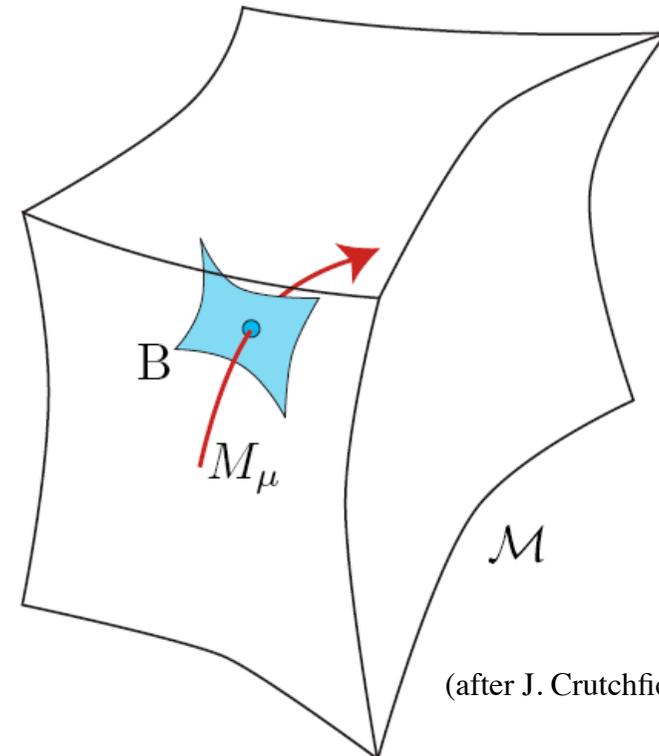
(after J. Crutchfield)

Precursors of 18 bifurcations

J Michael T Thompson (DAMTP, Cambridge)

| Precursors of codimension−one bifurcations (🔴 local decay rate of transients → 0)		
Supercritical Hopf	S: point to cycle	🔴 linearly with control c276a
Supercritical Neimark	S: cycle to torus	🔴 linearly with control
Supercritical flip	S: cycle to cycle	🔴 linearly with control
Band merging	S: chaos to chaos	lingers near impinging boundary
Flow explosion	E: point to cycle	🔴 linearly along folding path
Map explosion	E: cycle to torus	🔴 linearly along folding path
Intermittency expl: flow	E: point to chaos	🔴 linearly with control
Intermittency expl: map	E: cycle to chaos	🔴 as for trigger (fold, flip, Neimark)
Regular interior crisis	E: chaos to chaos	lingers near impinging saddle
Chaotic interior crisis	E: chaos to chaos	lingers near impinging saddle
Static fold	D: from point	🔴 linearly along folding path
Cyclic fold	D: from cycle	🔴 linearly along folding path
Subcritical Hopf	D: from point	🔴 linearly with control
Subcritical Neimark	D: from cycle	🔴 linearly with control
Subcritical flip	D: from cycle	🔴 linearly with control
Saddle connection	D: from cycle	period of cycle tends to infinity
Regular exterior crisis	D: from chaos	lingers near impinging saddle
Chaotic exterior crisis	D: from chaos	lingers near impinging saddle

Generic Prediction Phase Diagram

Interaction (coupling) strength

By classifying a system in a given regime, we can assert its degree of predictability.

SYNCHRONIZATION EXTREME RISKS

Coexistence of SOC and Synchronized behavior

10

1

0.1

0.01

SELF-ORGANIZED CRITICALITY

0.001

INCOHERENT

0.001   0.01   0.1   1   10

Heterogeneity - diversity
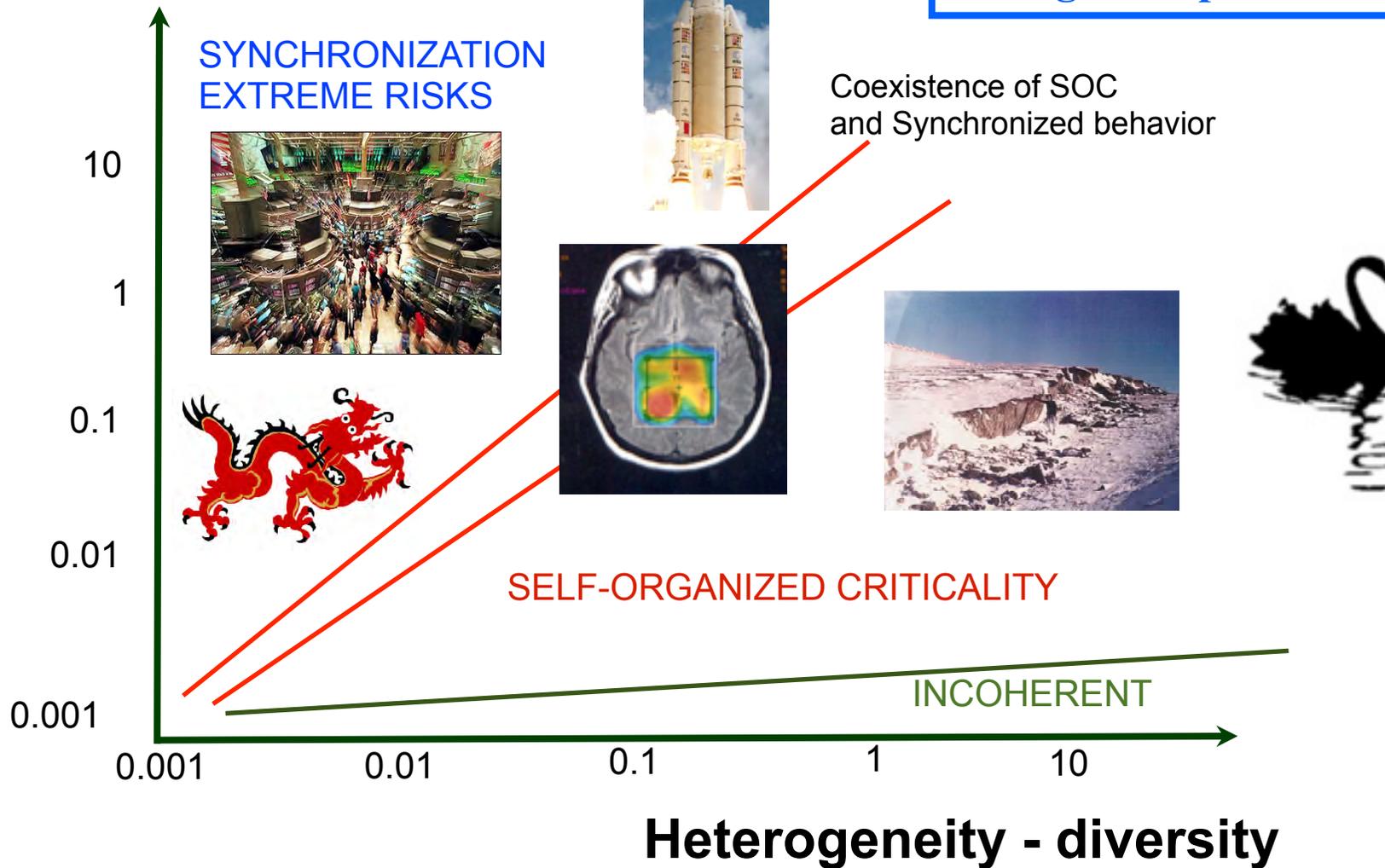
Bifurcations, catastrophes, phase transitions, tipping points...

are associated with...

"dragon-king" extreme events!

# Crises are not black swans but Dragon-kings

Black Swan (*Cygnus atratus*)

Dragon-king hypothesis

- Most crises are "endogenous"

  ★ can be diagnosed in advance,
    can be quantified, (some) predictability

- Moral hazard, conflict of interest, role of regulations

- Responsibility, accountability

- Strategic vs tactical time-dependent strategy

- Weak versus global signals

POSITIVE FEEDBACKS

Real Corporate Profits

After-tax domestic corporate profits with inventory and capital cost adjustments

### GDP share of US Financial Industry
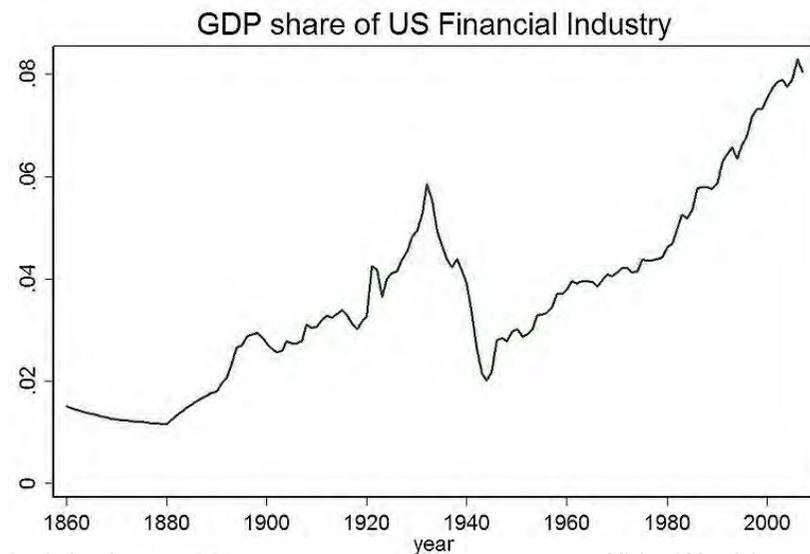
Positive feedbacks

The Law of Supply & Demand in Utilitarian Economics

Herding Impulse in Finance
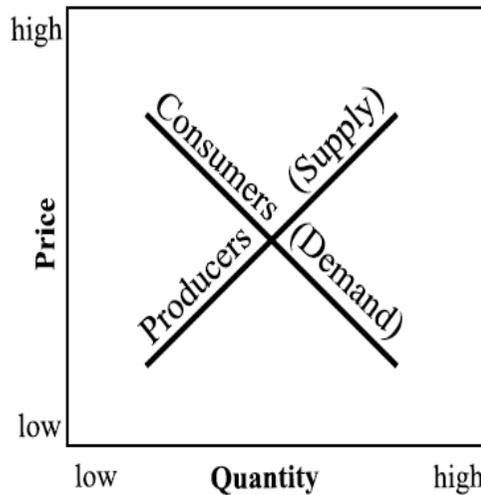
© 2003 Robert R. Prechter, The Socionomics Institute
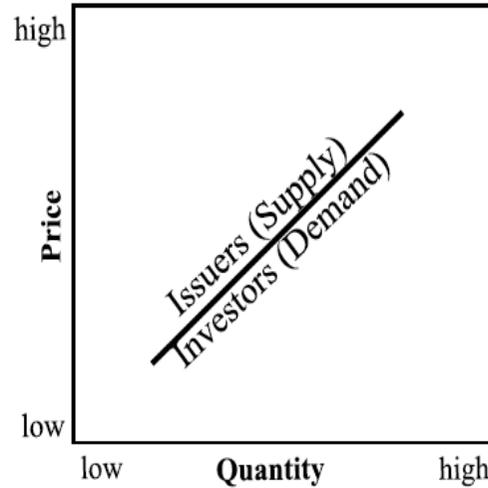
$$\frac{dp}{dt} = cp^d$$

$$p(t) = \left(\frac{c}{m}\right)^{-m} (t_c - t)^{-m}$$

$$m = 1/(d-1) > 0 \text{ and } t_c = t_0 + mp_0^{1-d}/c.$$
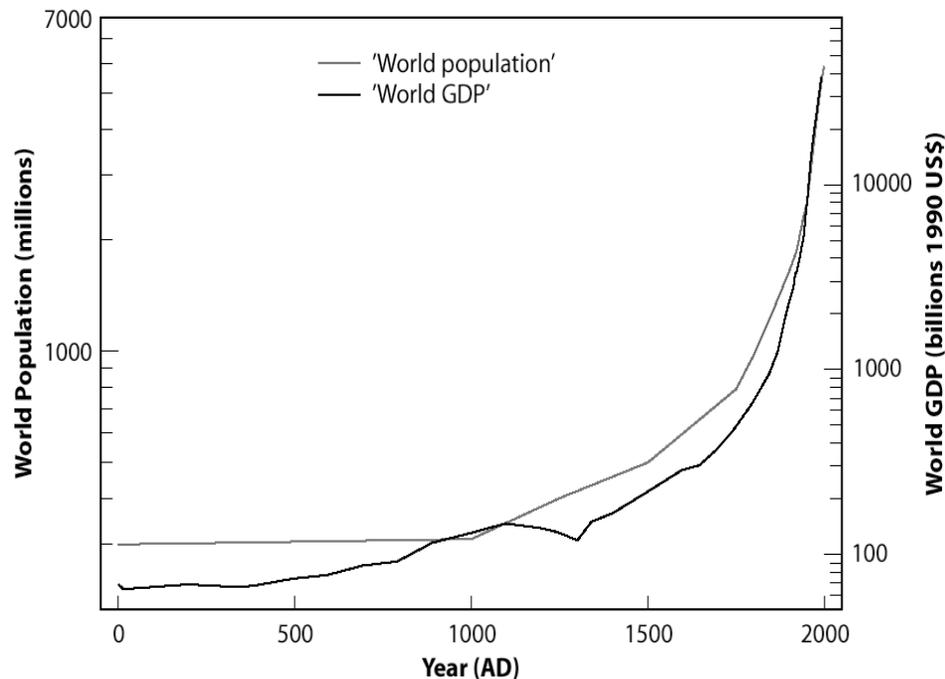
Bubble preparing a crisis:
Faster than exponential
transient unsustainable
growth of price

Paris as a dragon-king
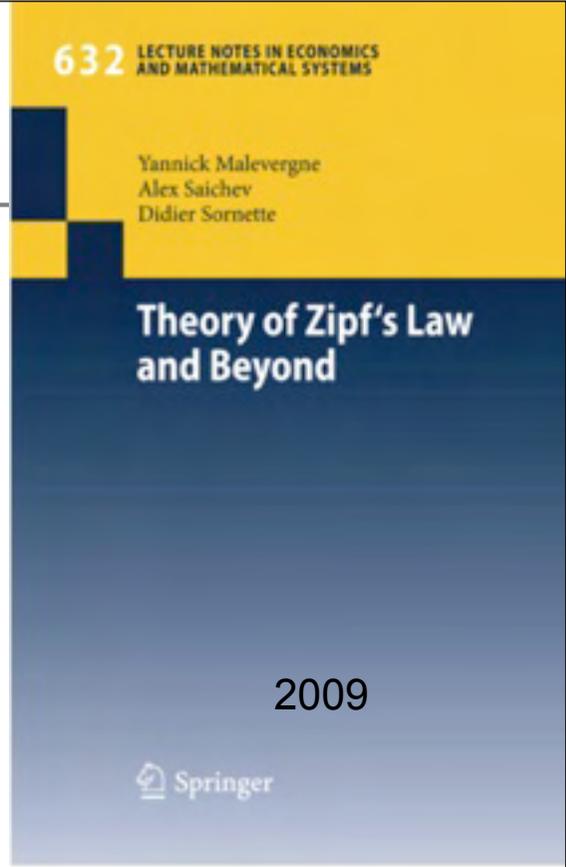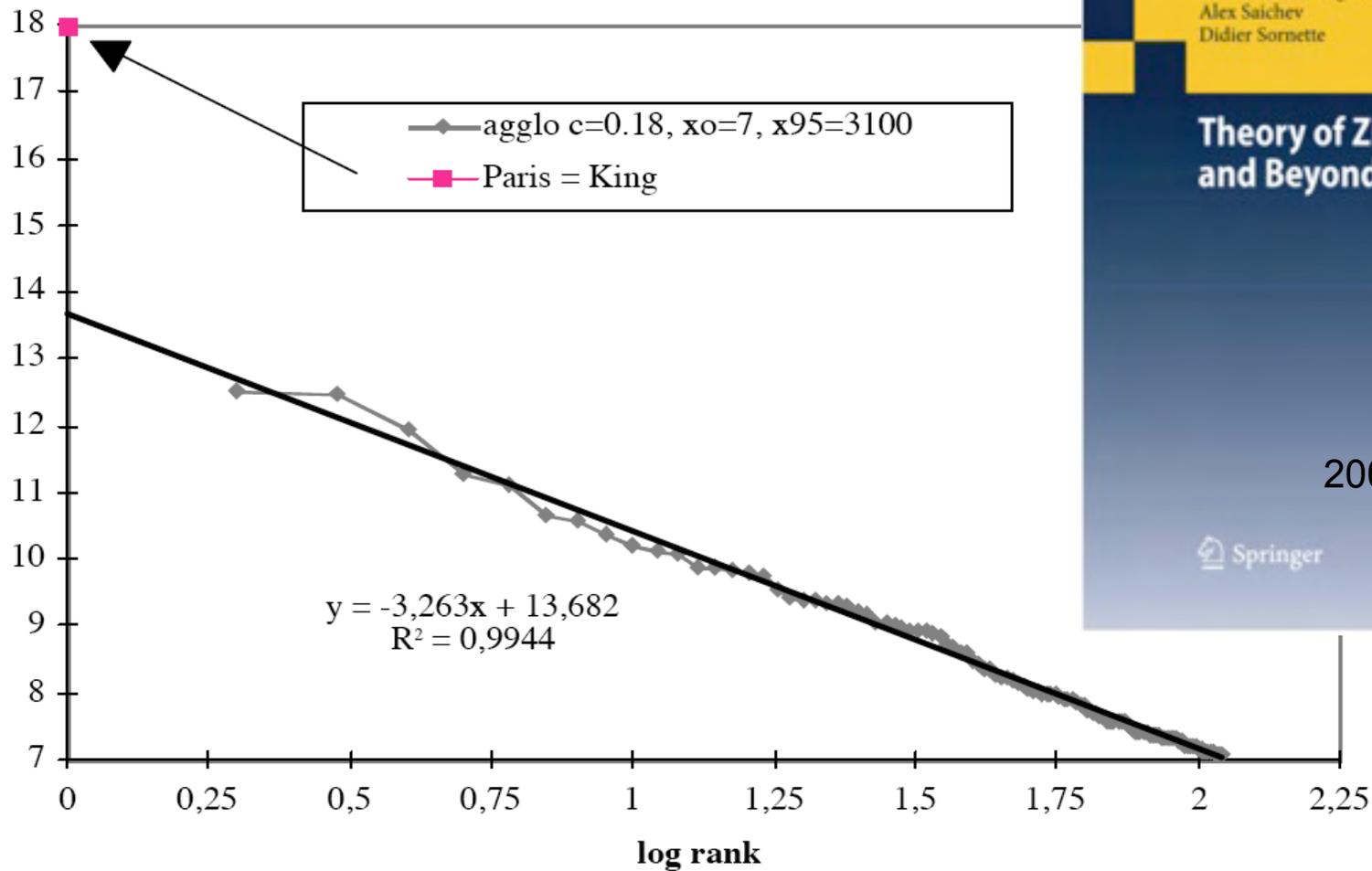
Fig. 7. French agglomerations: stretched exponential and "King effect".

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)

Extreme risks: Dragon-kings vs Black Swans

1. Geosciences of the solid envelop
1.1. Earthquake magnitude.
1.2. Volcanic eruptions.
1.3. Landslides.
1.4. Floods.

2. Meteorological and Climate sciences
2.1. Rains, hurricanes, storms.
2.2. Snow avalanches.

3. Material Sciences and Mechanical Engineering
3.1. Acoustic emissions.
3.2. Hydrodynamic turbulence.

4. Economics : financial drawdowns, distribution of wealth

5. Social sciences: distribution of firm sizes, of city sizes, of social groups...

6. Social sciences : wars, strikes, revolutions, city sizes

7. Medicine: epileptic seizures, epidemics

8. Environmental sciences : extinctions of species, forest fires
8.1. Evolution and extinction of species.
8.2. Forest fires.

Signs of Upcoming Transition

Early warning signals as predicted from theory

- Slower recovery from perturbations

- Increasing (or decreasing) autocorrelation

- Increasing (or decreasing) cross-correlation with external driving

- Increasing variance

- Flickering and stochastic resonance

- Increased spatial coherence

- Degree of endogeneity/reflexivity

- Finite-time singularities
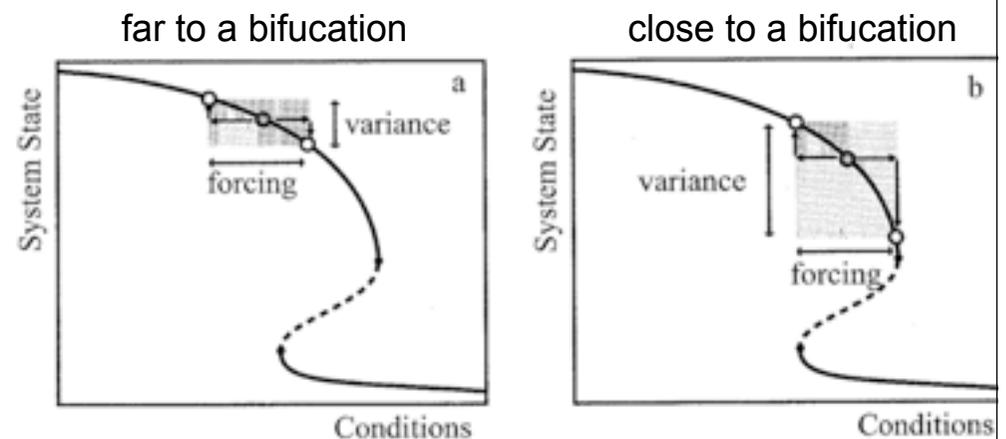
Financial Crisis Observatory

www.er.ethz.ch/fco

CHAIR OF ENTREPRENEURIAL RISKS

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ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

ETH Zurich - D-MTEC - Welcome to the Chair of Entrepreneurial Risks - Financial Crisis Observatory

Financial Crisis Observatory

Financial Crisis Observatory
Description
Highlights
Is there an oil bubble?
Pertinent articles
Websites and Blogs
Market Anxiety Measures

The Financial Crisis Observatory (FCO) is a scientific platform aimed at testing and quantifying rigorously, in a systematic way and on a large scale the hypothesis that financial markets exhibit a degree of inefficiency and a potential for predictability, especially during regimes when bubbles develop.

Current analysis and forecasts
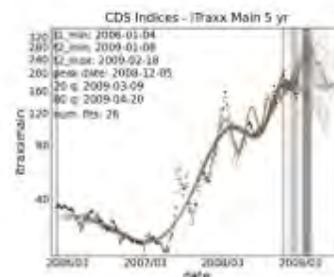
CDS (19 February 2009)
Our analysis has been performed on data kindly provided by Amjed Younis of Fortis on 19 February 2009. It consists of 3 data sets: credit default swaps (CDS); German bond futures prices; and spread evolution of several key euro zone sovereigns. The date range of the data is between 4 January 2006 and 18 February 2009. Our log-periodic power law (LPPL) analysis shows that credit default swaps appear bubbly, with a projected crash window of March-May, depending on the index used. German bond futures and European sovereign spreads do not appear bubbly. (See report for more information.)

OIL (27 May 2008)
Oil prices exhibited a record rise followed by a spectacular crash in 2008. The peak of $145.29 per barrel was set on 3 July 2008 and a recent low of $40.81 was scraped on 5 December, a level

The Financial Bubble Experiment
advanced diagnostics and forecasts of bubble terminations

•***Hypothesis H1**: financial (and other) bubbles can be diagnosed in real-time before they end.*

•***Hypothesis H2**: The termination of financial (and other) bubbles can be bracketed using probabilistic forecasts, with a reliability better than chance (which remains to be quantified).*

Methodology for diagnosing bubbles

- **Positive feedbacks of higher return anticipation**

  ✳ Super exponential price

  ✳ Power law "Finite-time singularity"

- **Negative feedback spirals of crash expectation**

  ✳ Accelerating large-scale financial volatility

  ✳ Log-periodic discrete scale-invariant patterns

Predictability of the 2007-XXXX crisis: 15y History of bubbles and Dragon-kings

- The ITC "new economy" bubble (1995-2000)

- Slaving of the Fed monetary policy to the stock market descent (2000-2003)

- Real-estate bubbles (2003-2006)

- MBS, CDOs bubble (2004-2007)

- Stock market bubble (2004-2007)

- Commodities and Oil bubbles (2006-2008)

Ex-ante diagnostic of bubbles and timing of crashes

NASDAQ ICT 2000

Real-estate UK mid-2004

Real-estate USA mid-2006
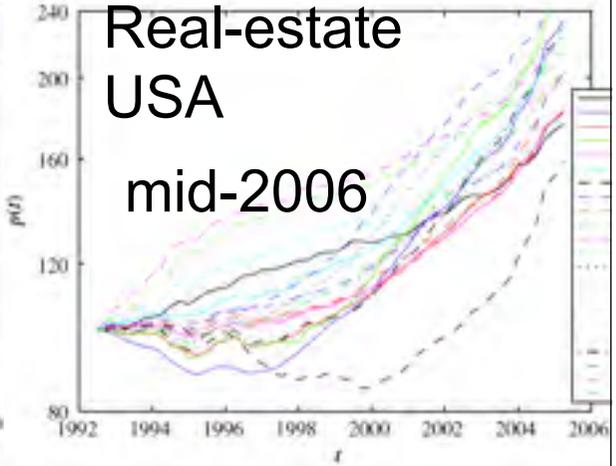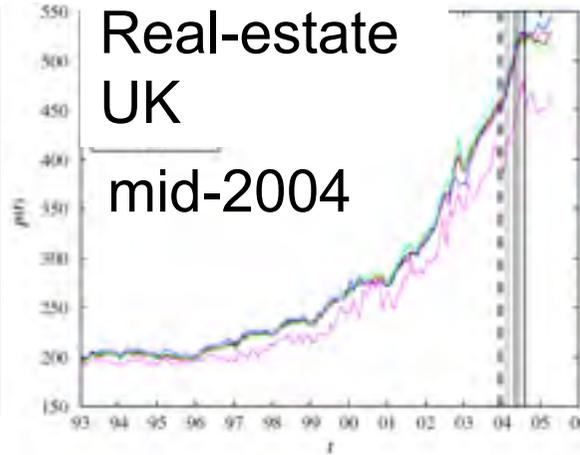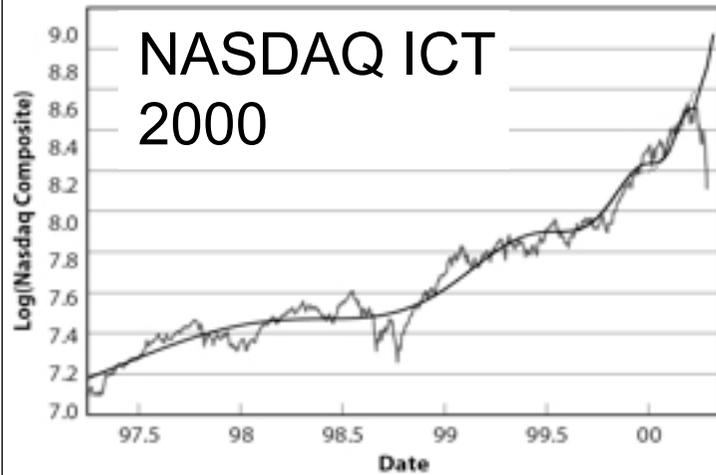
Oil July 2008
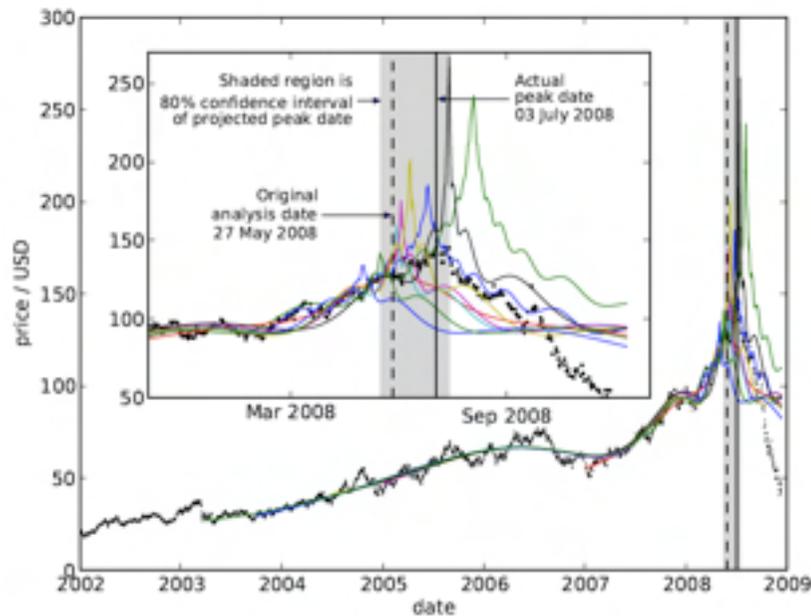
S&P500 USA Oct. 2007

Ex-ante diagnostic of bubbles and timing of crashes

CORN

GOLD

SOYBEAN

WHEAT
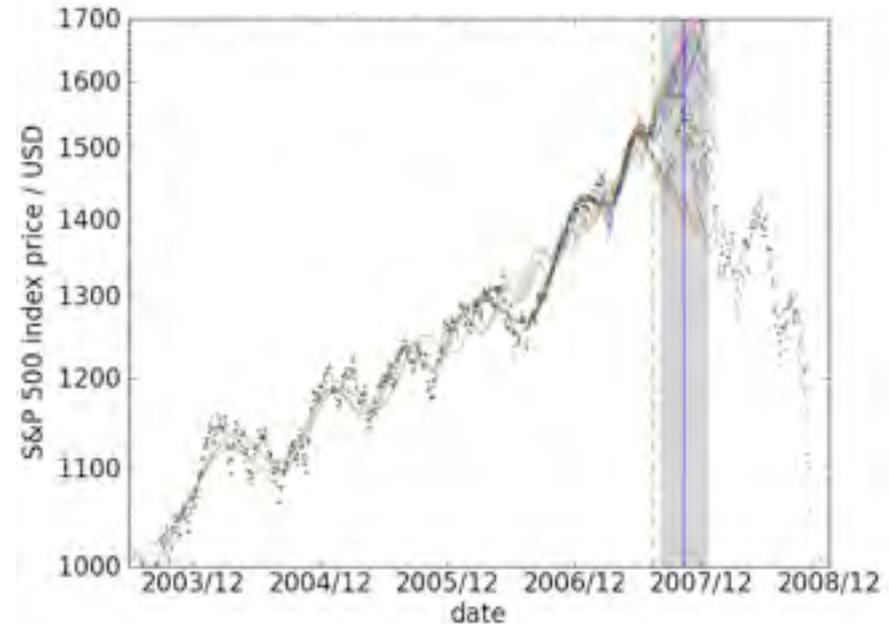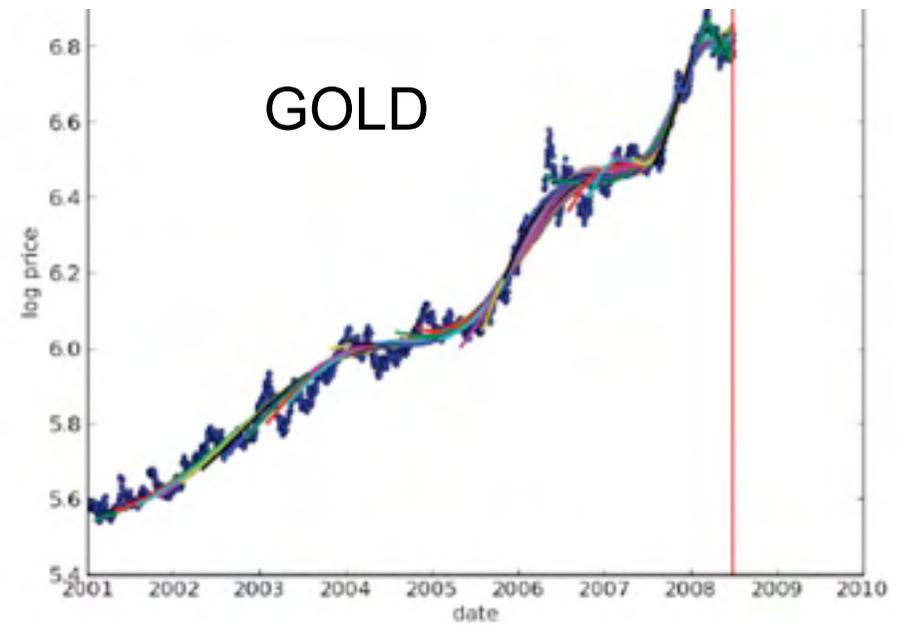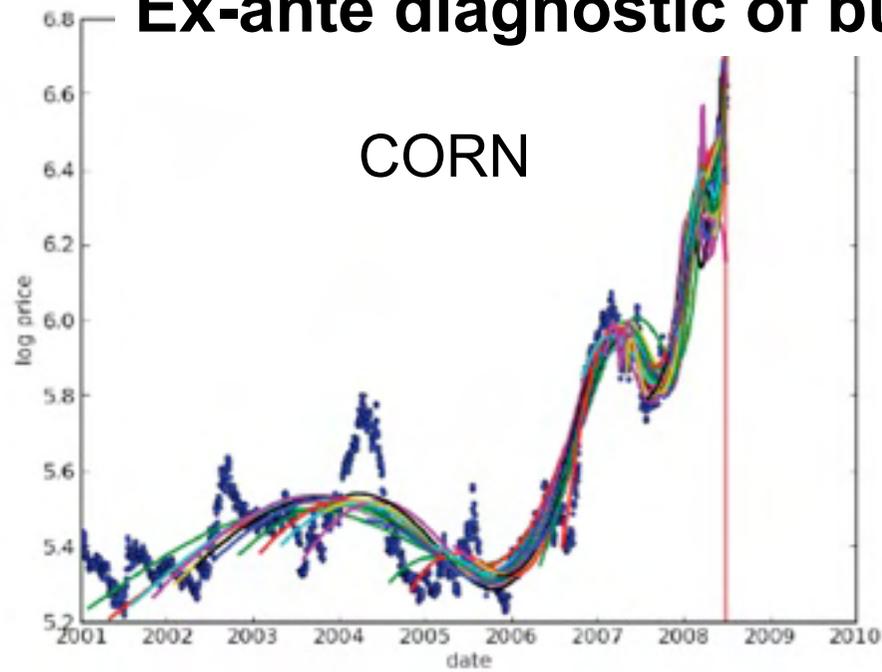
R.Woodard and D.Sornette (2008)
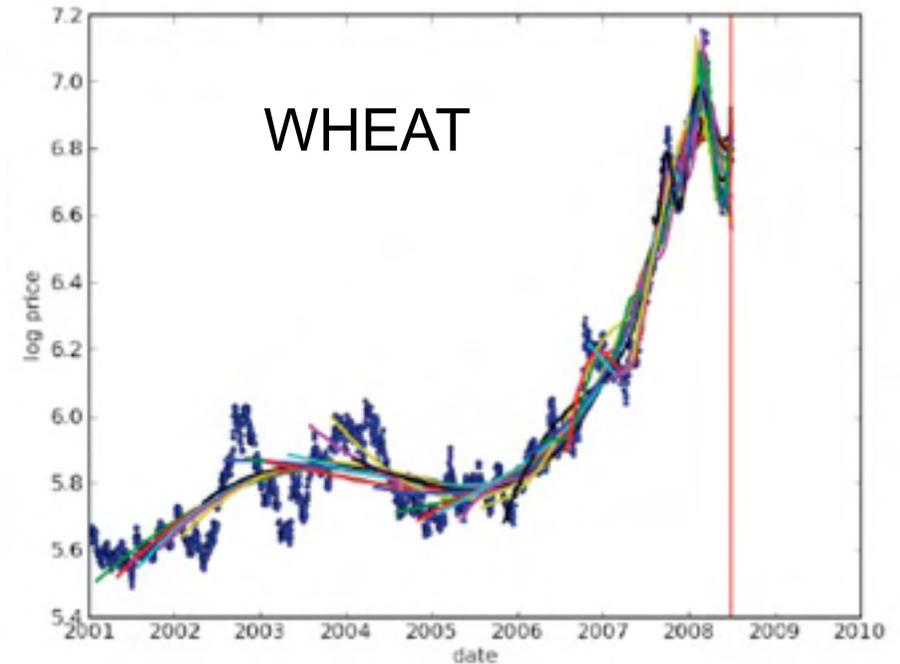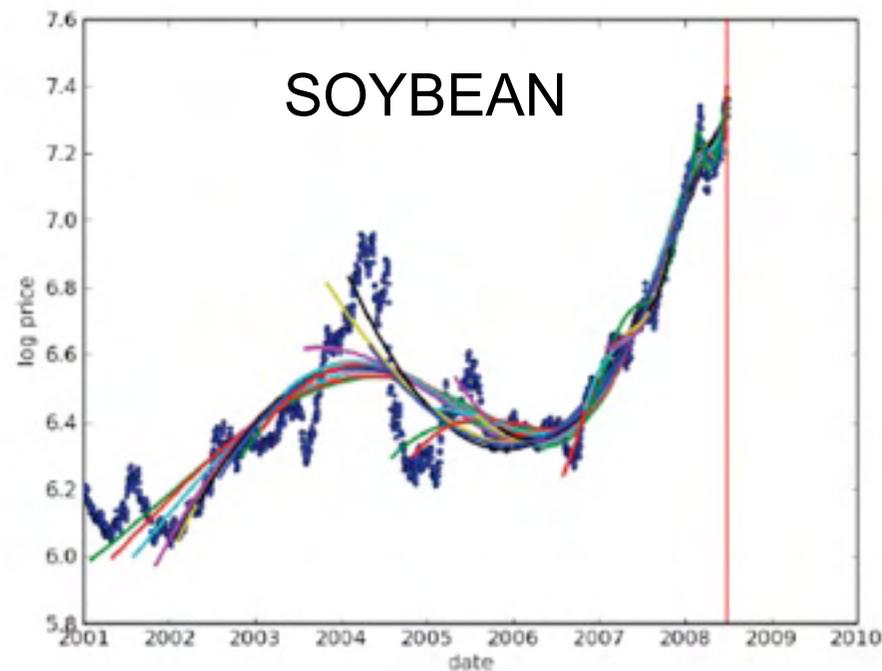
Ex-ante diagnostic of bubbles and timing of crashes
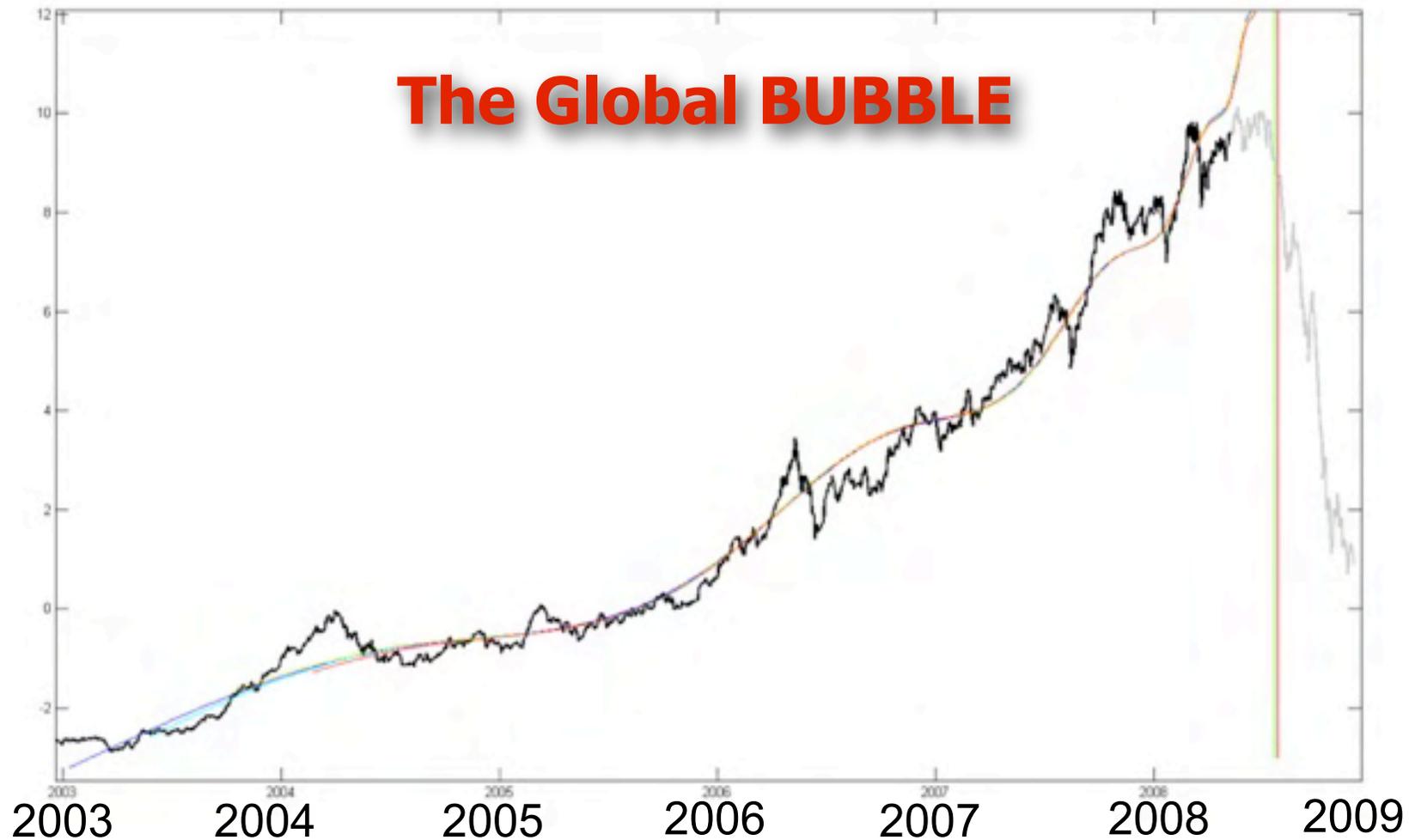
PCA first component on a data set containing, emerging markets equity indices, freight indices, soft commodities, base and precious metals, energy, currencies...

(Peter Cauwels   FORTIS BANK - Global Markets)

Financial Crisis Observatory (FCO)

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Evolution of the project

The methodology has been developed and tested in the past fifteen years following different phases.

Phase 1: Ex-post analysis of bubbles and crashes

Development and testing of the methodology based on ex-post analysis of historical bubbles and crashes. A review can be found in the book "Why Stock Markets Crash", or in the overview of publications on our website: http://www.er.ethz.ch/publications/finance

Phase 2: Ex-ante prediction of bubbles and crashes

Prediction and publication, on an ad-hoc basis, of the risk of bubbles and crashes before the actual occurrence, examples:

• The US Real Estate Bubble (See: http://arxiv.org/abs/physics/0506027 – Submitted June 2005)
• The Oil Bubble (See http://arxiv.org/abs/physics/0506027 – Submitted June 2008)
• The Chinese Stock Market bubbles (See: http://arxiv.org/pdf/0909.1007.pdf and http://arxiv.org/ftp/arxiv/papers/0907/0907.1827.pdf - Submitted July 2009)

•Phase 3: Ex-ante prediction in the FBE experiment

The digital authentication key of a document with the forecasts is published on the internet. The contents of the document is only published after the event has passed to avoid any possible impact of the publication of the ex-ante prediction on the final outcome.
The results are published on http://www.er.ethz.ch/fco/index

Phase 4: Manual Trading

Getting out of the ivory tower of platonic modeling, testing, analyzing and publication. This is a real-money trading experiment with the purpose to thoroughly test and try to falsify our hypotheses in the Financial Markets Laboratory. This is the phase we are currently in. We trade equities, indices, ETFs, commodities and currencies. We use different strategies (hedged/unhedged, Long/Short, Spreads, Options, Gamma, Vol). The models are calibrated based on daily data series.

Phase 5: Algorithmic Trading

We are currently working on extending our manual trading into an automatic algorithmic trading process. This includes expanding our time resolution from daily data to intraday minute data. We want to apply this in liquid contracts like: equity index futures, EMINI, Bund Futures, Currencies, …
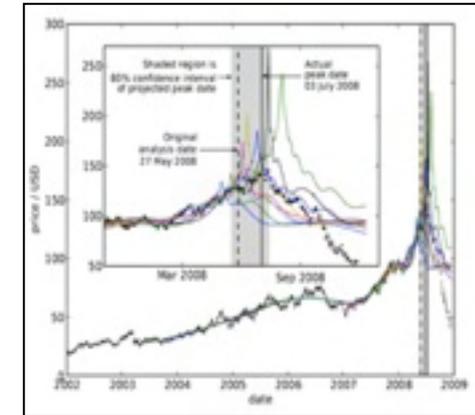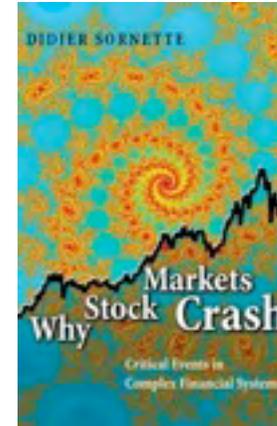
CHF Bubble (FXF – ETF)

Investment Strategies as "CAT scan" Spectroscopy of Financial Markets to detect bubble regimes

Global indexes: 2007 - 2008 long

Investment Strategies as "CAT scan" Spectroscopy of Financial Markets to detect bubble regimes

Global indexes: 2011 - 2012 long
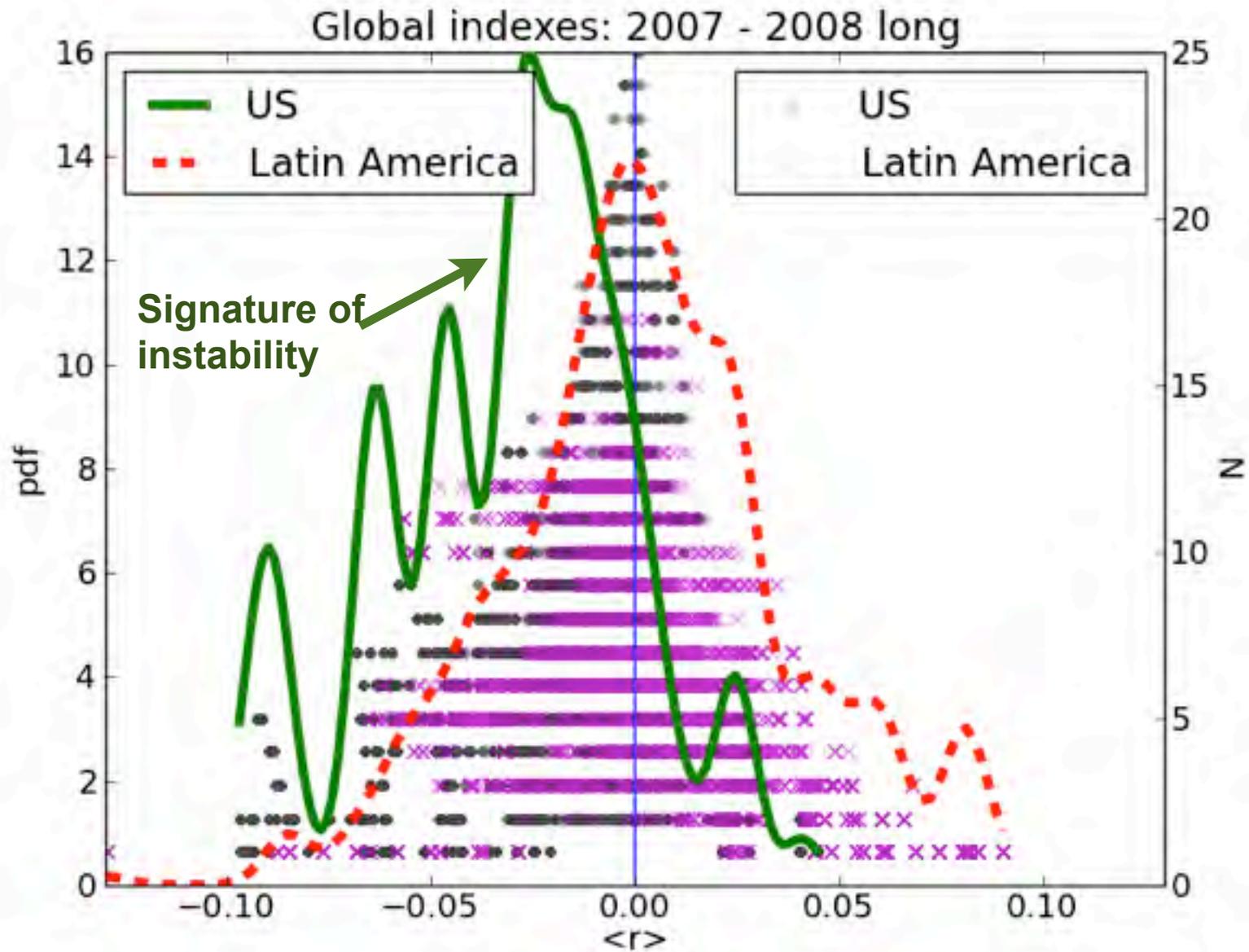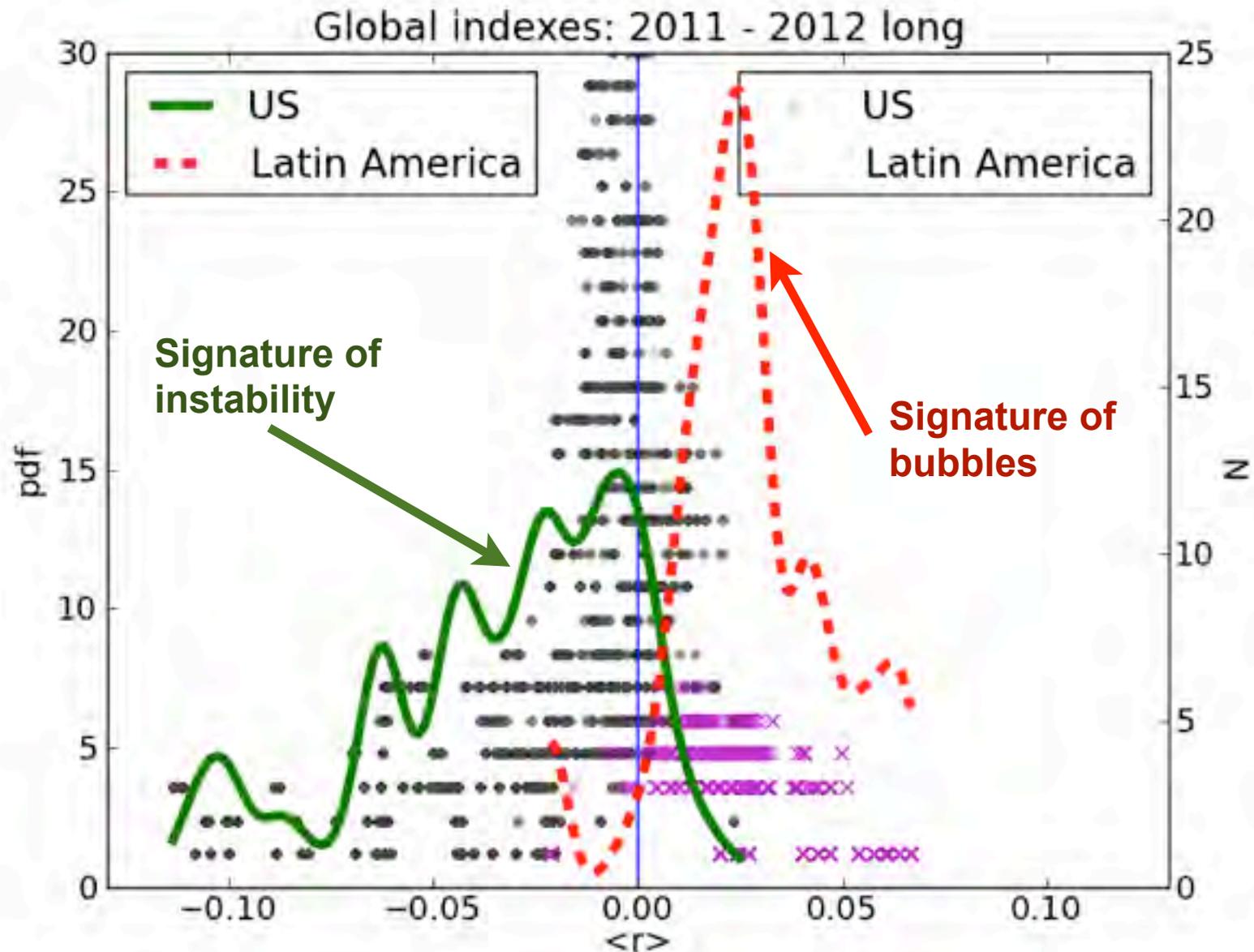
Are solutions requiring increasing complexity?

Innovations?

What about remembering well-known solutions?

Solutions for Financial and biological Health?

The problem of institutional and academic memory loss

- Glass-Steagall act (1933)

- Credit creation by banks (S. Keen, R. Werner,...)

The key question: is there evidence that the new financial innovations and a much expanded bank system has brought any real gain for innovations, economic development, employment?

Proposition: put back the banks at the service of the economy

Generic Prediction Phase Diagram

Interaction (coupling) strength

By classifying a system in a given regime, we can assert its degree of predictability.

SYNCHRONIZATION
EXTREME RISKS

Coexistence of SOC
and Synchronized behavior

10

1

0.1

0.01

SELF-ORGANIZED CRITICALITY

0.001

INCOHERENT

0.001   0.01   0.1   1   10

Heterogeneity - diversity
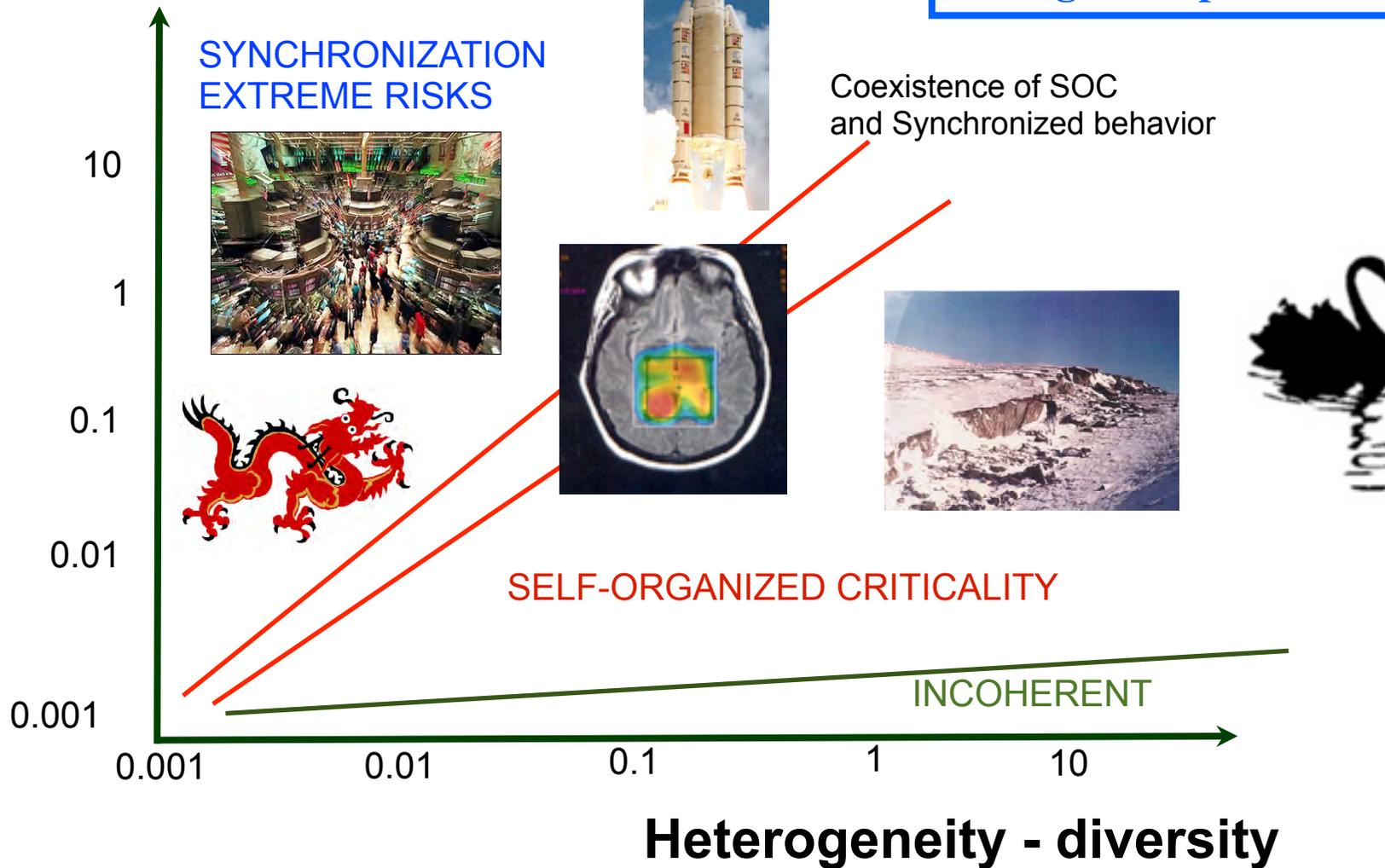
Resilience at the individual level

1) **Sleep**: Rest with quality sleep for a minimum of 7-8 hours per night;

2) **Love and sex**: Fall in love. Cultivate the romance and relationship; interrupt your work when needed with one minute of intense focus on the loved one, perhaps using romantic or sexy pictures of him/her to trigger happiness hormones that boosts brain performance and well-being. Make love as often as possible with your special partner.

3) **Deep breathing and daily exercises**: Start each of your day (no exception) with 5-10 minutes of exercises, including deep breathing-stretching followed by abdominal and finishing with a very short intense workout; perform a few 2-3 minutes of intense workouts and deep breathing at different times of your day in your office or wherever you happen to be in order to oxygen your body and refresh your brain;

4) **Water and chewing**: Drink at least 2 liters of water per day (no canned juice, no coke, no beer, no sugar) outside meals and drink minimally or not at all during meals (a small glass of red wine or cup of hot green tea is fine); "drink your food" and "eat your drinks".

Resilience at the individual level

5) **Fruits, unrefined products, food combination, vitamin D and sun exposure and no meat and no dairy: Eat as much fruits with water as possible on an empty stomach during the day,** avoid meat and consume only unrefined products and cereals; avoid bad food combination to avoid conflicts between alkaline versus acid foods.

6) **Power foods**: onion, garlic, lemon, kiwis, almonds, nuts, dry fruits for super-performance in time of intense demand.

7) **Play, intrinsic motivation, positive psychology and will**: rediscover the *homo ludens* in yourself in things small and large so that work and life become a large playground, cultivate motivation as a self-reinforcing positive feedback virtuous circle.

WWW.**LOGIC**-WORKOUT.com

French health, Swiss engineering

(Paul-Emmanuel Sornette)

Logic Workout uniqueness and efficiency:

- it uses **unstable and asymmetric exercises**: individual muscles are not overtrained. Moreover all the fibers in the muscles are trained.

- there are no breaks: because exercises train different muscles each time, one group of muscles rests while another is training. And it trains endurance.

- each session is 45 minutes.

-One/two sessions per week is enough for amazing results.

If you want to be full of energy, avoid wounds and outperform in sports, Logic Workout is the 45 minutes per week training you need to face these life challenges.

Results and Stories

"How I build muscle for my leg after after tendon surgery". Paul-Emmanuel Sornette

"How I can now do one hand pushups to rest, recuperating from a shoulder injury" Didier Sornette

Windsurfing with helicopter wind

Didier Sornette
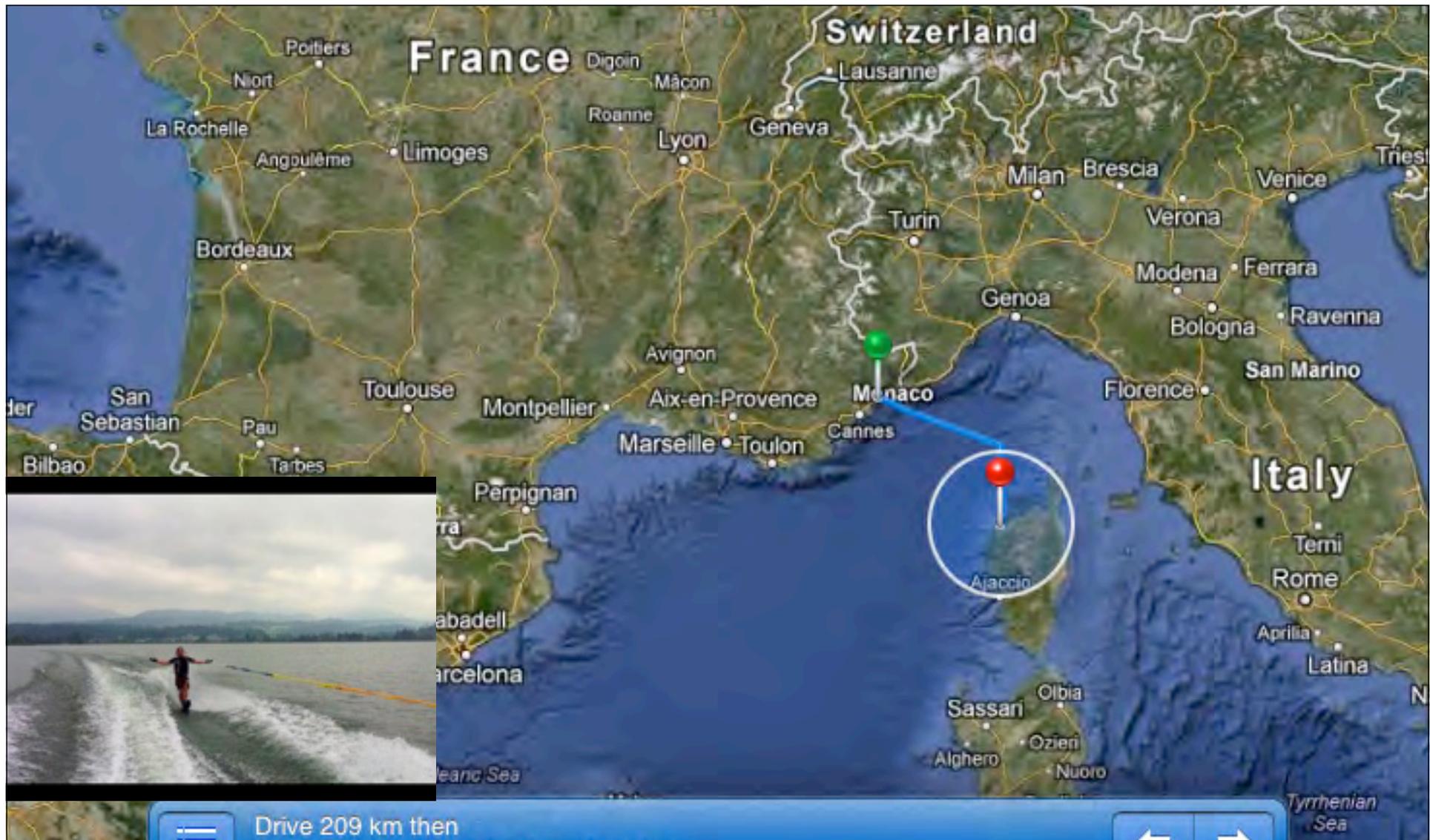
130 miles from Nice France
to Calvi Corsica waterskiing

Didier and Paul-Emmanuel Sornette

Big problems are piling up...

Suggested solutions:

-diagnose endogenous instabilities

-diversify

-decouple

-work on incentives and motivations

-"strengthen" individuals

Further Reading

D. Sornette, Dragon-Kings, Black Swans and the Prediction of Crises, International Journal of Terraspace Science and Engineering 2(1), 1-18 (2009) (http://arXiv.org/abs/0907.4290)

D. Sornette and R. Woodard Financial Bubbles, Real Estate bubbles, Derivative Bubbles, and the Financial and Economic Crisis (preprint at http://arxiv.org/abs/0905.0220) will appear in the Proceedings of APFA7 (Applications of Physics in Financial Analysis, http://www.thic-apfa7.com/en/htm/index.html)

D. Sornette and G. Ouillon, Dragon-kings: mechanisms, statistical methods and empirical evidence, European Physical Journal Special Topics   (2012) (special issue on power laws and dragon-kings)

Didier Sornette, Why Stock Markets Crash (Critical Events in Complex Financial Systems) Princeton University Press, January 2003

Y. Malevergne and D. Sornette, Extreme Financial Risks (From Dependence to Risk Management) (Springer, Heidelberg, 2006).

Endogeneity vs Exogeneity

Extinctions
- meteorite at the Cretaceous/Tertiary KT boundary
- volcanic eruptions (Deccan traps)
- self-organized critical events

Financial crashes
- external shock
- self-organized instability

Immune system
- external viral or bacterial attack
- " internal" (dis-)organization

Brain (learning)
- external inputs
- internal self-organization and reinforcements (role of sleep)

Aviation industry recession
- September 11, 2001
- structural endogenous problems

Recovery after wars?
- internally generated (civil wars)
- externally generated

Discoveries
- serendipity
- maturation

Volatility bursts in financial time series
- external shock
- cumulative effect of "small" news

Earthquakes
- tectonic driving
- triggering

Parturition
- mother/foetus triggered?
- mother-foetus complex?

Commercial success and sales
- Ads
- epidemic network

Social unrests
- triggering factors
- rotting of social tissue