The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

1864-34

Ninth Workshop on Non-linear Dynamics and Earthquake Predictions

1 - 13 October 2007

Universality of Premonitory Phenomena: Transformation of Scaling

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Universality of Premonitory Phenomena:
Transformation of Scaling

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- Moscow State University
- Institute of Mathematics & Mechanics, Russian Ac. Sci. (Ekaterinburg)
- Vernadsky State Geological Museum, Russian Ac. Sci.
- UCLA
- MIT
- UC Davis
- Purdue University
- USGS
- LA Dept of Water and Power
- Los Alamos Natl. Laboratory
- LA Police Department
- The Abdus Salam International Centre for Theoretical Physics, Trieste
- University of Trieste
- University of Rome, La Sapienza
- EU Int. School for Public Policy Studies, Luxembourg
- Institut de Physique du Globe de Paris
- Ecole Normale Supérieure (Paris)
- Observatoire de la Côte d'Azur
- Geophysical Institute of Israel
- University of Tel Aviv
- The Hebrew University of Jerusalem
- Council for Disaster Preparedness, Govt. of Israel
- Natl. Center for Physics, Islamabad
- Natl. Institute of Geophysics, Hyderabad

Intermittent collaboration with disaster management organizations in Russia, Italy, US, and reinsurance companies in Russia, Switzerland, and Spain.

Coping with the lack of fundamental equations

"It became clear for me that it is unrealistic to have a hope for the creation of a pure theory [of the turbulent flows of fluids and gases] closed in itself.

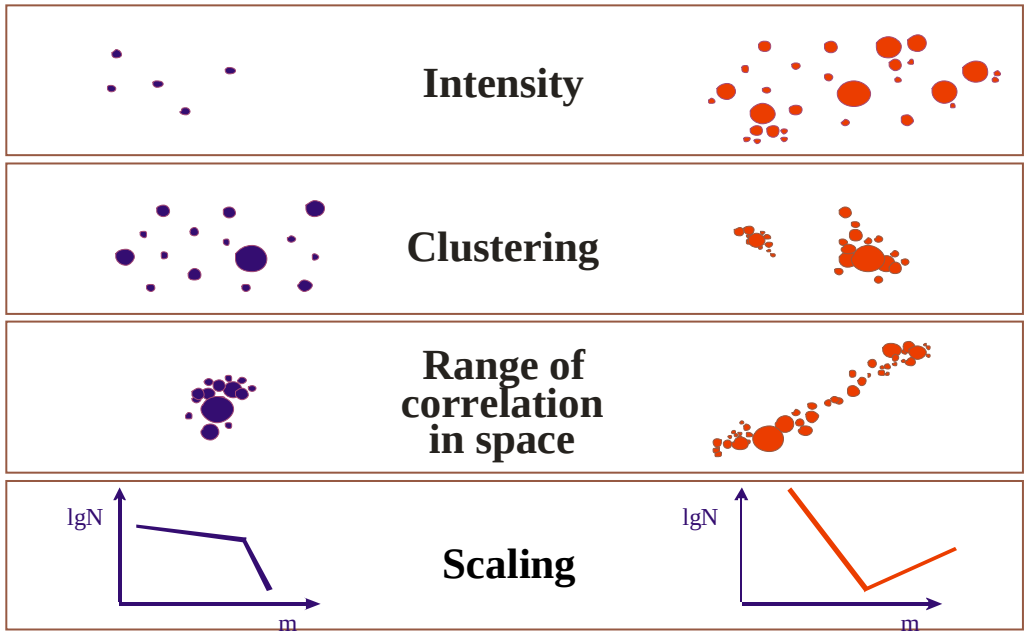
Due to the absence of such a theory we have to rely upon the hypotheses obtained by processing of the experimental data."

A. Kolmogorov.

BASIC TYPES OF PREMONITORY PHENOMENA

An extreme event is preceded by the following changes in relevant observed fields:

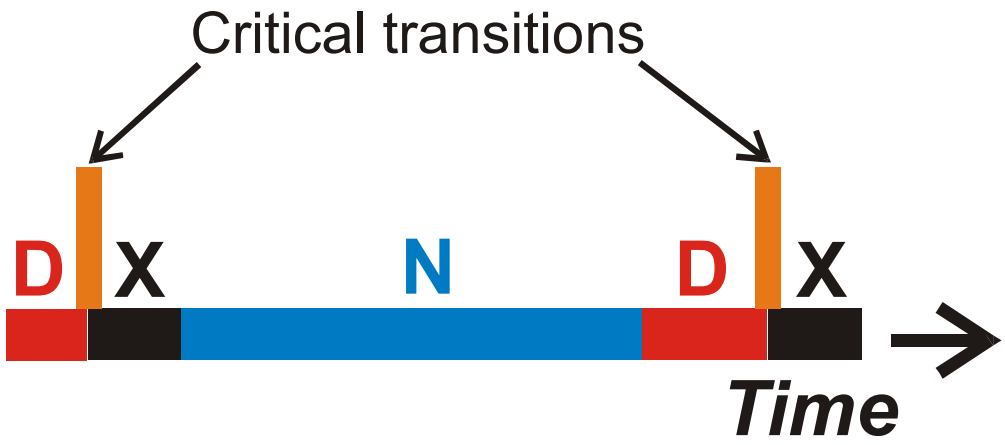
Safe state



Pre-disaster state

These phenomena are reminiscent of asymptotics near the phase transition of second kind. However, we consider not the return to equilibrium, but the growing disequilibrium, culminated by an extreme event.

COMPARING SCALING CLOSE TO AND FAR FROM CRITICAL TRANSITIONS

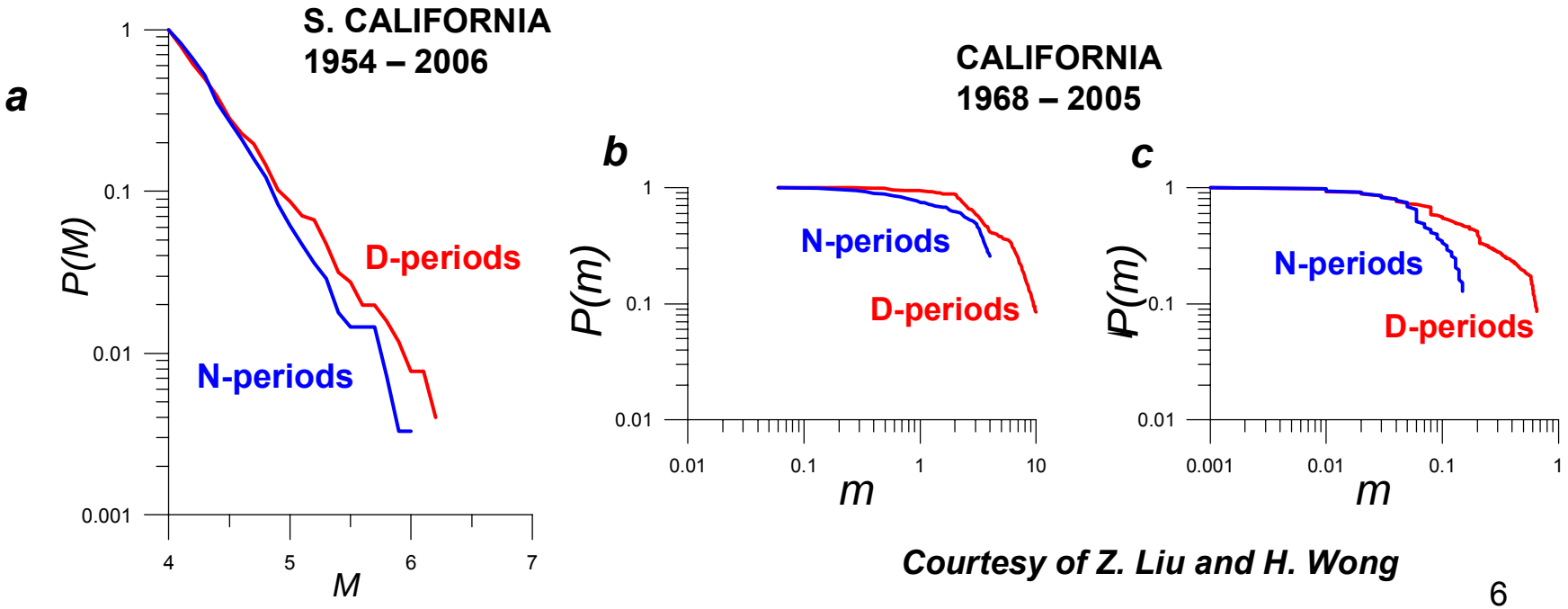


- **Time is divided into periods of three kinds:**
  D - preceding a critical transition; X - following it;
  N – other time intervals
- ***N(m)* - the number of events of the size ≥ *m*;**
  useful normalization: *N(m)* = *Ň* P(m) where *Ň* is the total number of events.
- **We compare *N(m)* in periods D and N. Their difference demonstrates predictive power of scaling.**
- **Application to individual events requires further analysis**

A POINT OF DEPARTURE – EARTHQUAKES

Critical transitions **(prediction targets)** are main shocks with ***M*** ≥ 6.4,
M being the logarithmic measure of energy released by an earthquake.
P(m) is the probability that magnitude of an event is ≥ ***m.***

a: event is an individual main shock.
b, c: event is a cluster of aftershocks around an individual main shock.
Cluster's size is measured in number of aftershocks not weighted (***b***)
or weighted (***c***) by their magnitudes.



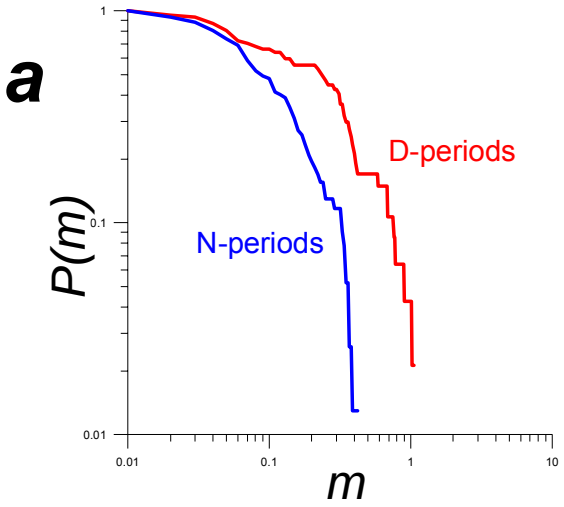
Courtesy of Z. Liu and H. Wong

SOCIO-ECONOMIC CRISES

Critical transitions **(prediction targets)** are the starting points of a respective crisis.
Size distribution P(m) is probability that the size of an event is **≥ *m*.**

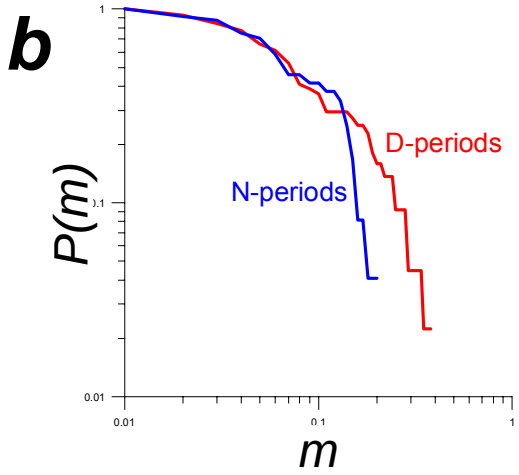
Event is the change of the trend of a monthly indicator considered:
a , ***b*** - industrial production; ***c*** - assaults with firearms

US RECESSIONS 1961-2002



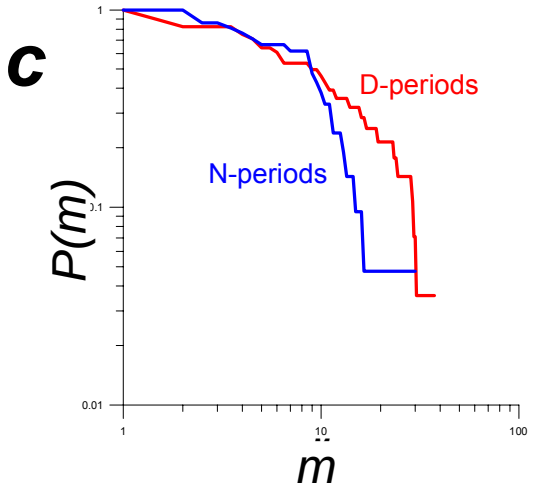
http://www.igpp.ucla.edu/prediction/ref/Pre-recession.pdf

UNEMPLOYMENT SURGES, US, 1961 - 2005



http://www.igpp.ucla.edu/prediction/ref/Homicide.pdf

HOMICIDES SURGE, LOS ANGELES, 1975 – 1993

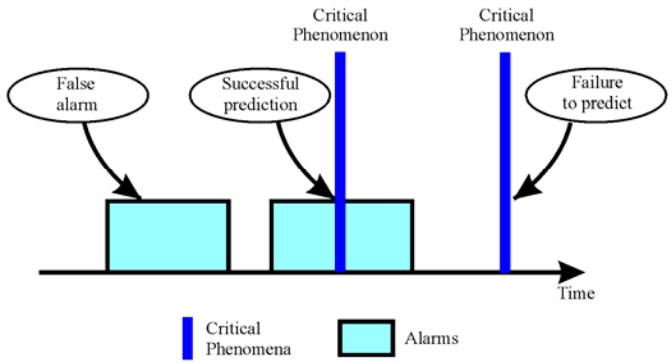


http://www.igpp.ucla.edu/prediction/ref/Unemployment.pdf

PREDICTING INDIVIDUAL EVENTS

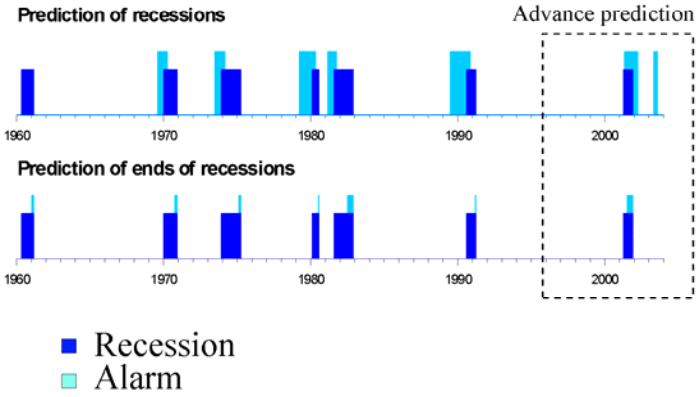
SOCIO-ECONOMIC PREDICTIONS

Outcomes of prediction

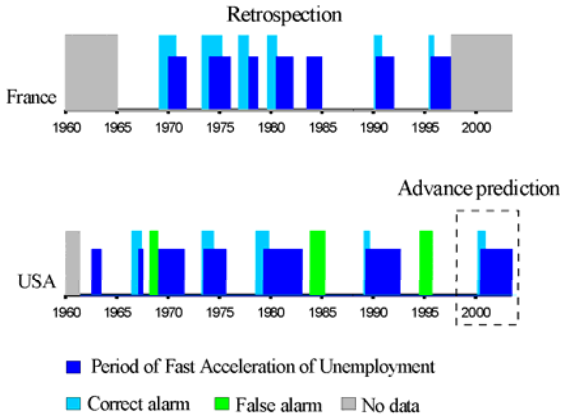


Probabalistic nature of prediction is represented by probability gain and probabilities of false alarms and failures to predict.

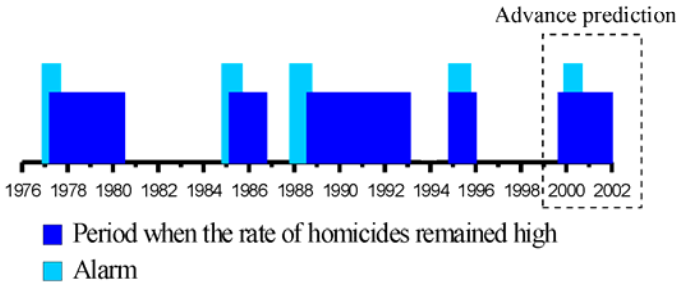
Prediction of US recessions



Prediction of surges of unemployment



Prediction of homicide surges



C.B.Allegre, D.J.Gascon, M.D.Intrigator, V.I.Keilis-Borok, P.Mikhalev, R.Pichardo, A.N.Sobolevskii, A.A.Soloviev, J.Stock, F.E.Winberg

PREDICTION OF US PRESIDENTIAL ELECTIONS

(Lichtman, A. J., 2000. *The Keys to the White House*, Lexington Books, 208 p.)

Prediction is based on thirteen socio-economic and political factors.
All six made-in-advance predictions were correct.

***Predictions** (published months in advance)*

0	1	2	3	4	5	6	7	8	9
					2000*				
				1984	1988	2004	1996	1992	

Retrospective Analysis

0	1	2	3	4	5	6	7	8	9
			1964					1980	
			1928					1976	
			1916					1968	
			1908					1952	
		1944	1900	1972				1932	
	1956	1940	1872	1924	1948	1912	1884	1920	1960
1904	1936	1868	1864	1880	1888*	1892	1860	1896	1876*

Number of factors in favor of challenger

*** years when popular vote was reversed by electoral vote.**

Red - incumbent won, blue – challenger won.
Victory of challenging party is predicted when 6 or more factors are in its favor.
Otherwise victory of incumbent party is predicted. Prediction algorithm is the same for all years.
Data for 1860 – 1980 was used in designing the algorithm.

PREDICTION OF US MID-TERM SENATORIAL ELECTIONS SINCE 1986

0	1	2	3	4	5	6	7
			OK98				
			CO98				
			FL98				
			GA98				
			HA98	TN02			
			ID98	SC02			
			MA98	NC02			
			ND98	NE02			
			PN98	KY02			
			SD98	IA02			
			UT98	CO02			
			FL94	AL02			
			HA94	AK98			
			IN94	CA98			
			MT94	CT98			
			NB94	NE98			
			NJ94	OR98			
			TX94	SC98			
			WA94	VT98			
		AS98	WV94	WA98			
		KA98	WI94	CT94			
		LA98	AK90	MD94			
		MI98	IN90	NV94			
		NH98	KN90	WY94			
		MS94	ME90	CO90			
	AL98	NM94	MA90	HA90			
	AZ98	ND94	MT90	KY90			
	IO98	RI94	NB90	MI90			
	DL94	VT94	NC90	AZ86			
	MA94	AS90	TX90	CO86			
	NY94	IO90	WY90	ID86			
	AL90	MS90	AR86	LA86			
	DE90	NM90	CA86	NY86			
	IL90	OR90	IL86	OK86	WI98	MN94	
	LA90	RI90	IN86	WI86	CA94	MO94	
	OK90	SD90	IA86	**NC86**	ID90	VA94	
	SC90	VA90	NH86	**WA86**	PA86	NH90	
	TN90	WV90	OR86	**MN90**	**IL98**	**IN98**	
	HI86	AK86	VT86	**OK94**	**ME94**	**OH98**	
	OH86	CT86	**TN94**	**PA94**	**AL86**	**MI94**	
UT94	SC86	KS86	**TX02**	**TN294**	**FL86**	**MD86**	**KY98**
GA90	UT86	KY86	**OK02**	**NC98**	**GA86**	**NV86**	**AZ94**
NJ90	**NH02**	**ND86**	**NJ02**	**NY98**	**MO86**	**SD86**	**OH94**
0	1	2	3	4	5	6	7

Prediction is based on eight socio-economic and political factors. Victory of challenging party is predicted if 5 or more factors are in its favor. Otherwise victory of incumbent party is predicted.

Table compares prediction and the outcome of elections. Letters indicate the state, figures - the year of election.

Red - incumbent won,
Blue – the challenger won.
Light blue - errors

128 of 150 predictions have been correct

EARTHQUAKE PREDICTION: SCORING

Algorithms M8&MSc, since 1985.
11 out of 15 M8+ earthquakes have been captured by M8 alarms occupying altogether 33% of the time-space considered.
9 of them have been captured by MSc alarms occupying 17% of time-space.

Algorithm SSE since 1989
30 predictions have been made.
24 were correct; among 6 errors are
2 failures-to-predict a second strong earthquake and
4 false alarms.