ESC - S07: 8052

3rd EUROPEAN CONFERENCE ON
EARTHQUAKE ENGINEERING & SEISMOLOGY
BUCHAREST, ROMANIA, 2022

Seismic Roulette

Invited Presentation

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ESC - Session 07: Advances in Statistical Seismology: from earthquake occurrence to risk assessment

Об оценках сейсмической опасности и предсказуемости землетрясений

Владимир КОСОБОКОВ

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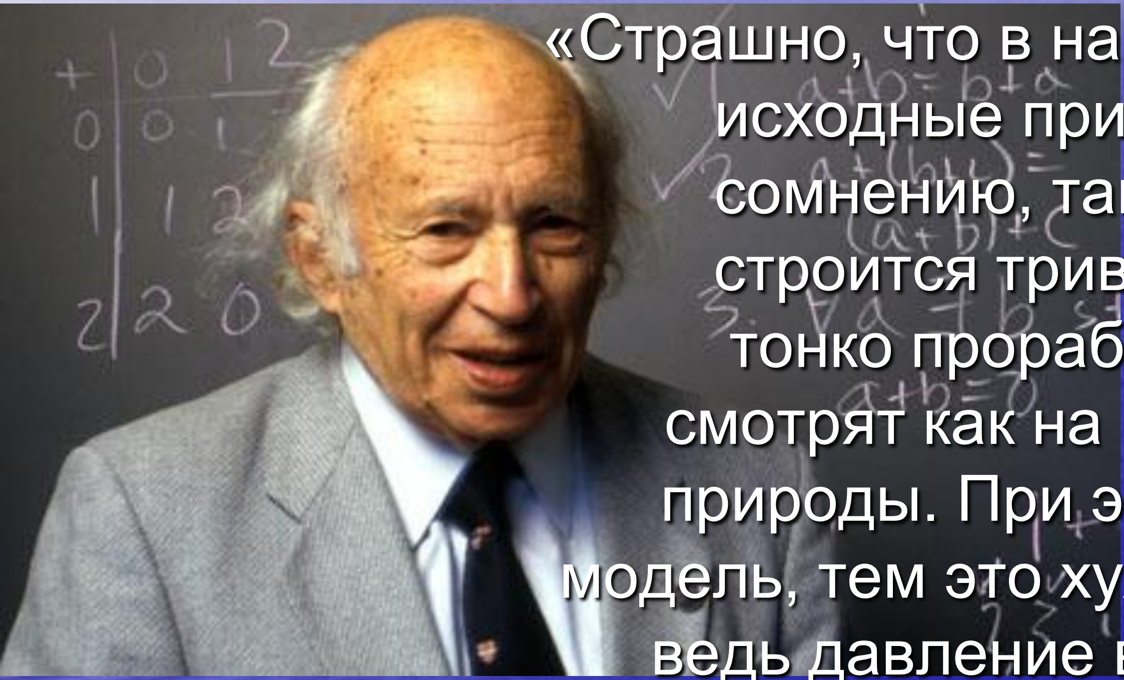
И.М. Гельфанд

ДВА АРХЕТИПА В ПСИХОЛОГИИ ЧЕЛОВЕЧЕСТВА

1989 Лекция при вручении премии INAMORI FOUNDATION
(Киото, Япония)

Izrail M. Gelfand, Two archetypes in the psychology of Man. Nonlinear Sci. Today 1 (1991), no. 4, 11



«Страшно, что в наш технократический век исходные принципы не подвергаются сомнению, так что когда на их основе строится тривиальная или, наоборот, тонко проработанная модель, на нее смотрят как на полную замену явления природы. При этом чем лучше сделана модель, тем это хуже для ее применений - ведь давление выхваченных "исходных принципов" выводит модель еще дальше за пределы ее применимости.»

Израиль Моисеевич Гельфанд (1913-2009)

И.М.Гельфанд
ДВА АРХЕТИПА В ПСИХОЛОГИИ ЧЕЛОВЕЧЕСТВА
Лекция при вручении премии INAMORI FOUNDATION
(1989 - Киото, Япония)

« 7. Ответственность математиков.

…

Но может быть, еще большая ответственность, … , состоит в том, чтобы противодействовать неразумному и опасному использованию точных математических и логических систем за пределами их применимости.

…

Ибо кто, кроме математиков, может помочь предупредить о злоупотреблении ею в наш технократический век.»

Andrea Saltelli and Daniel Sarewitz, “Reformation in the Church of Science,” *The New Atlantis*, Number 68, Spring 2022, pp. 56–64. https://www.thenewatlantis.com/publications/reformation-in-the-church-of-science

- We are suffering through a pandemic of lies — or so we hear from leading voices in media, politics, and academia. Our culture is infected by a disease that has many names: fake news, post-truth, misinformation, disinformation, mal-information, anti-science. The affliction, we are told, is a perversion of the proper role of knowledge in a healthy information society.

Мы страдаем от пандемии лжи — по крайней мере, так мы слышим от ведущих голосов в СМИ, политике и научных кругах. Наша культура заражена болезнью, у которой много названий: фейковые новости, постправда, ложная информация, дезинформация, недостоверная информация, антинаука. Нам говорят, что эта болезнь **— извращение надлежащей роли знания в здоровом информационном обществе**.

Stark, P. B. (2022). Pay no attention to the model behind the curtain. Pure and Applied Geophysics. https://doi.org/10.1007/s00024-022-03137-2.

- Many widely used models amount to an elaborate means of making up numbers—but once a number has been produced, it tends to be taken seriously and its source (the model) is rarely examined carefully. Many widely used models have little connection to the real-world phenomena they purport to explain. Common steps in modeling to support policy decisions, such as putting disparate things on the same scale, may conflict with reality. Not all costs and benefits can be put on the same scale, not all uncertainties can be expressed as probabilities, and not all model parameters measure what they purport to measure.

Многие широко используемые модели представляют собой сложные средства ***сочинения чисел***, но после того, как ***число*** получено, к нему обычно относятся серьезно, а его ***источник (модель) редко тщательно исследуют***. Многие широко используемые модели имеют мало связи с явлениями реального мира, которые они призваны объяснить. Обычные шаги в моделировании для поддержки политических решений, такие как сравнение несопоставимого на одной шкале, могут противоречить действительности. Не все затраты и выгоды можно расположить на одной шкале, не все неопределенности можно выразить как вероятности, и не все параметры модели измеряют то, что они должны измерять.

Abstract:

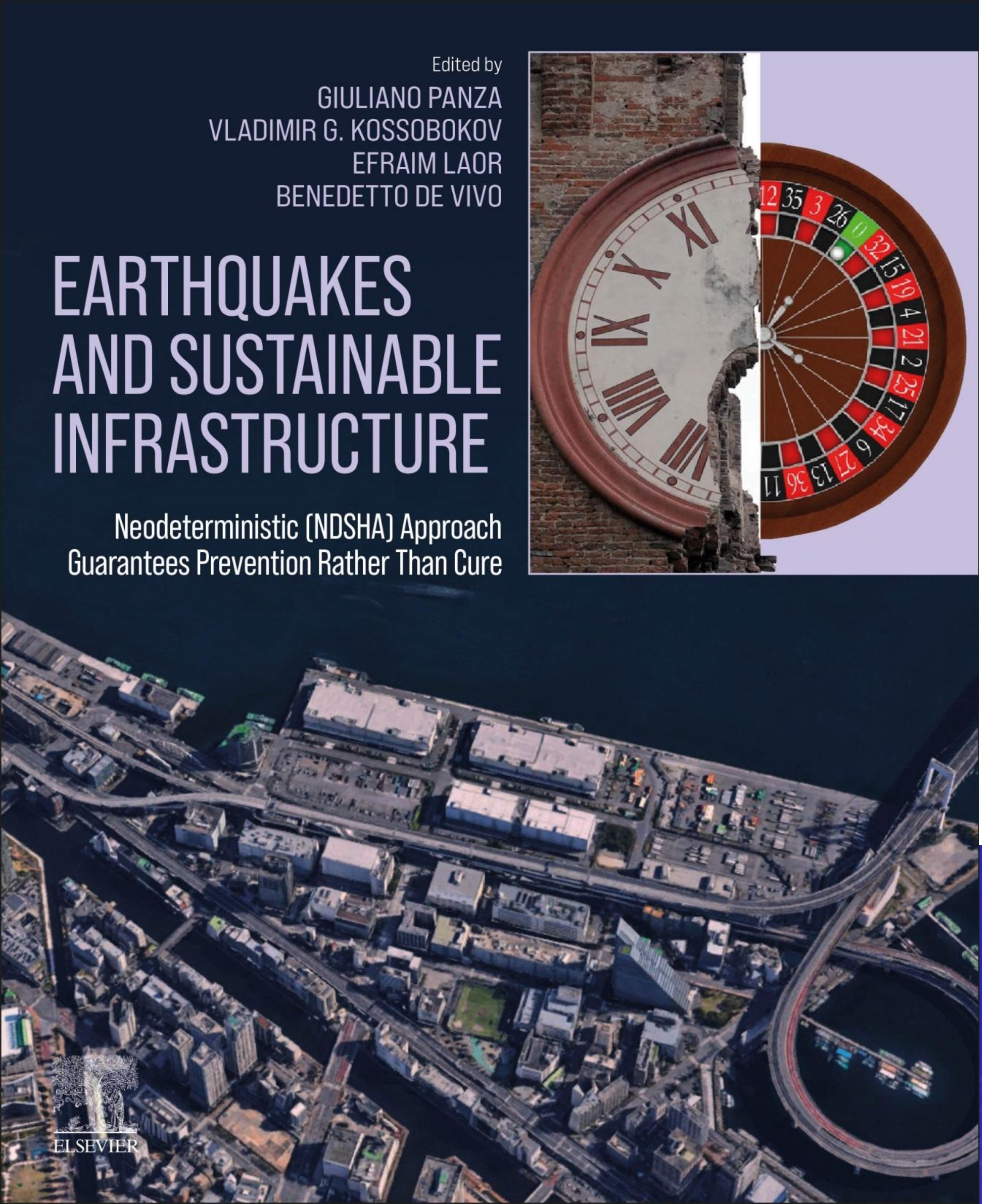
Nowadays, Science can disclose Natural Hazards, assess Risks, and deliver the state-of-the-art Knowledge of looming disaster in advance catastrophes along with useful Recommendations on the level of risks for decision making in regard to engineering design, insurance, and emergency management. Science cannot remove, yet, people's favor for illusion regarding reality, as well as political denial, ignorance, and negligence among decision-makers. The general conclusion is confirmed by application and testing against earthquake Reality.

Regretfully, most, if not all, of earthquake prediction claims are "invented" due to very small, if any, sample of clearly defined evidence. The necessity and possibility of applying simple tools of Earthquake Prediction Strategies – Error Diagram and Seismic Roulette null-hypothesis as a metric of the alerted space – are evident. Seismic Roulette is not perfect! Therefore, seismic hazard assessment and earthquake prediction claims can be useful for reducing future impacts from disastrous earthquakes, if reliable, but not necessarily perfect.

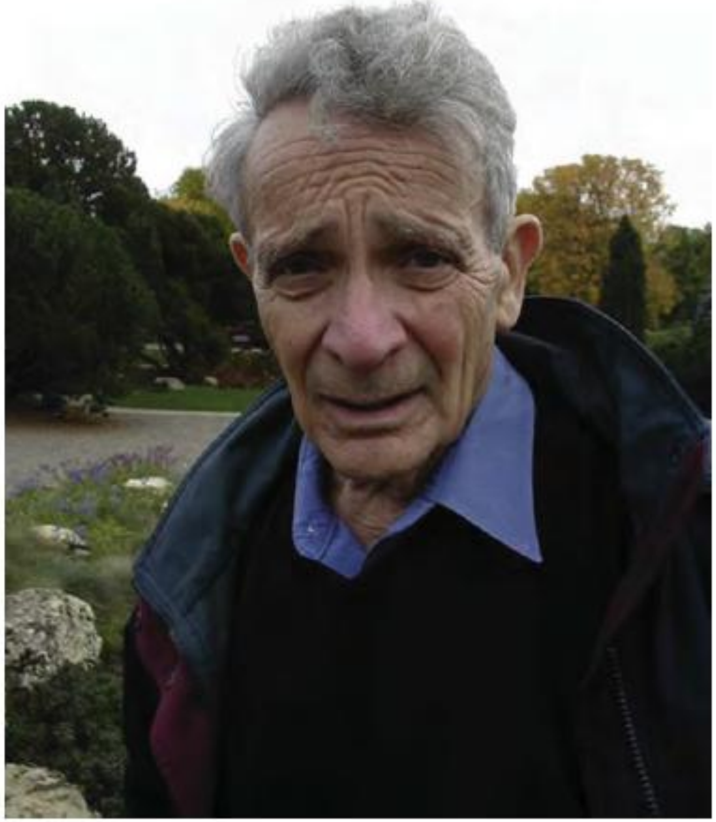
АННОТАЦИЯ:

В настоящее время наука может обнаруживать природные опасности, оценивать риски и предоставить самые современные знания о надвигающихся бедствиях заблаговременно вместе с полезными рекомендациями по уровню рисков, необходимые для принятия решений в отношении инженерного проектирования, страхования и управления чрезвычайными ситуациями.

Наука пока не может устранить склонность людей к мифам и иллюзиям относительно реальности, а также политического отрицания, искреннего невежества и сознательной небрежности лиц, принимающих решения. Этот общий вывод подтверждается применением и тестированием инновационной методологии Нео-детерминистской Оценки Сейсмической Опасности (Neo-Deterministic Seismic Hazard Assessment, NDSHA), которая «гарантирует предотвращение, а не устранение» ущерба от землетрясений (Panza, Kossobokov, Laor, & DeVivo, 2021). Результаты NDSHA основаны на надежных сейсмических данных, распознавании закономерностей в районах, подверженных землетрясениям (Pattern Recognition of Earthquake Prone Areas, PREPA), следствиях Общего Закона Подобия для Землетрясений (Unified Scaling Law for Earthquakes, USLE) и исчерпывающем моделировании сотрясений грунта на основе физически обоснованных сценариев.



In memory and to the centenary of Vladimir I. Keilis-Borok



Vladimir Isaakovich Keilis-Borok (31.07.1921–19.10.2013)

Книга содержит 30 глав, в которых рассматриваются исследования NDSHA и результаты, полученные для территорий Европы, Азии, Америки и Африки.

Contents


World Conference on Disaster Reduction
18-22 January 2005, Kobe, Hyogo, Japan
Thank you for
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Contents lists available at SciVerse ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

Advance prediction of the March 11, 2011 Great East Japan Earthquake: A missed opportunity for disaster preparedness

C. Davis [a,*], V. Keilis-Borok [b,c], V. Kossobokov [c,d], A. Soloviev [c]

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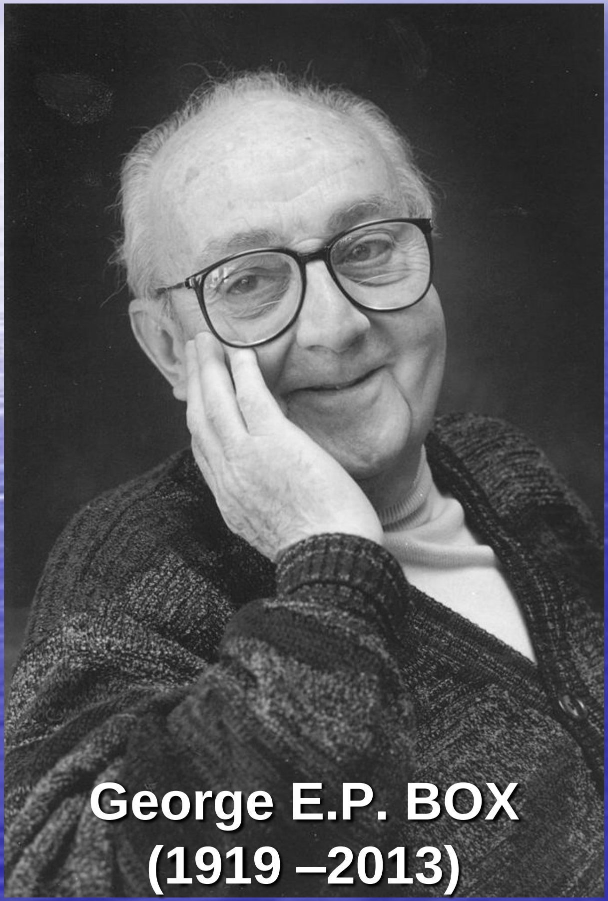
[c] Institute of Earthquake Prediction Theory and Mathematical Geophysics, Russian Academy of Sciences, 84/32 Profsouznaya, Moscow 117997, Russia
[d] Institut de Physique du Globe de Paris, 1 Rue Jussieu, 75238 Paris Cedex 05, France

(2) no practicing application of existing methodologies to guide emergency preparations and policy development on how to make decisions based on information provided for an intermediate-term middle-range earthquake prediction having limited but known accuracy". (Davis et al., 2012)

"All models are wrong but some are useful".



George E.P. BOX
(1919 –2013)

"…there is no need to ask the question "Is the model true?". If "truth" is to be the "whole truth" the answer must be "No". The only question of interest is "Is the model illuminating and useful?"

[Box, G. E. P. (1979), "Robustness in the strategy of scientific model building", in Launer, R. L.; Wilkinson, G. N., Robustness in Statistics, Academic Press, pp. 201–236.]

Some models are useful, some are useless, and some are Really harmful.

Evidently, we do not live in a black-and-white world and our beliefs in initial basic principles may lead us to models that contradict with the real observations. We know that “all models are wrong but some are useful” [Box, G. E. P. (1979), "Robustness in the strategy of scientific model building", in Launer, R. L.; Wilkinson, G. N., Robustness in Statistics, Academic Press, pp. 201–236.] but often forget that some models are useless and some are really harmful, especially, when viewed as substitutes for the original natural phenomena.

We are living in a risky world and are doomed to making predictions and actions. When we predict what to do, the choice of action is usually based on a comparison of expected “black eyes” (costs) and “feathers in caps” (benefits). If the latter exceed the former it is reasonable to go forward. In some cases, like crossing a highway, our decision is simple due to data enough for a reliable assessment of “black eyes” based on recollections of collective attitude and knowledge. However, in many practical cases, we do not have any opinion on impending consequences and, therefore, may end up when it is too late for effective countermeasures to reduce or even avoid a disaster.

Open data in a Big Data World provides unprecedented opportunities for enhancing studies of the Earth System.
However, it also opens wide avenues for finding deceptive associations in inter- and transdisciplinary data and for inflicted misleading predictions and wrong decisions.

PUBLISHED SUNDAY, OCTOBER 8, 2000, IN THE *SAN JOSE MERCURY NEWS* ©2000 DR. SAM SAVAGE

The Flaw of Averages

IF YOU COUNT ON THE STOCK MARKET'S AVERAGE RETURN
TO SUPPORT YOU IN RETIREMENT, YOU COULD WIND UP PENNILESS

By Sam Savage

"The only certainty is that nothing is certain."
So said the Roman scholar Pliny the Elder. And some 2000 years later, it's a safe bet he would still be right. The Information Age, despite its promise, also delivers a dizzying array of technological, economic and political uncertainties. This often results in an error I call the Flaw of Averages, a fallacy as fundamental as the belief that the earth is flat.

The Flaw of Averages states that: Plans based on the assumption that average conditions will occur are usually wrong.

A humorous example involves the statistician who drowned while fording a river that was, on average, only three feet deep.

But in real life, the flaw continually gums up investment management, production planning and other seemingly well-laid plans. The Flaw of Averages is one of the cornerstones of Murphy's Law (What can go wrong does go wrong).

Wrong! Given typical levels of stock market volatility there are only slim odds that the fund will survive the full time.

The following charts simulate this retirement strategy with actual S&P 500 returns starting in various years.

Notice that the level of average returns over any particular 20-year period is no guarantee of success. The real key is to get off to a good start, which is what separates 1974 from its neighbors.

For this example the Flaw of Averages states that: If you assume each year's growth at least equals the average of

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by his boss to...
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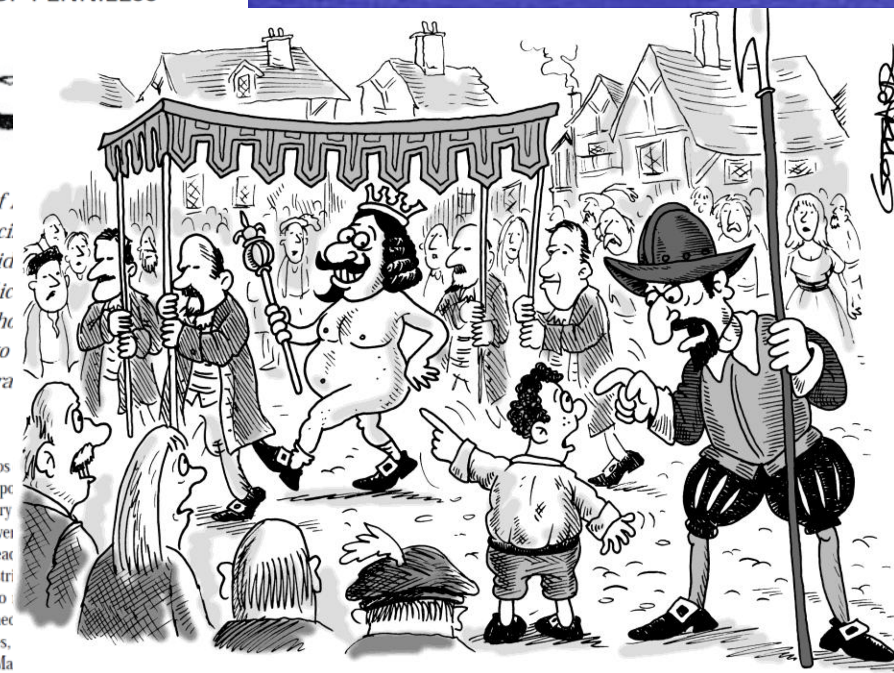
theory, which was stri...
Markowitz. "I said to ...
resulting portfolio theo...
and average outcomes, ...
him a Nobel Prize. Ma...

The only certainty is that nothing is certain.

Gaius Plinius Secundus (79), Naturalis Historia, II-7.



"I'm arresting you for bringing the Emperor into disrepute."

While prediction is "the act of saying what you think will happen in the future" even the advanced tools of data analysis may lead to erroneous claims. "And the better the model, the worse it becomes for its applications. Indeed, the pressure of snatching 'initial principles' will lead us to use the model well beyond the possibilities of its application" ***[The Inamori Foundation Kyoto Prize Commemorative Lecture of the 1989 Laureate in Basic Sciences: Izrail M. Gelfand, Two archetypes in the psychology of Man. Nonlinear Sci. Today 1 (1991), no. 4, 11].***

We are living in a world of numbers and calculations. Without numbers there are no odds and no probabilities. Especially, nowadays, in a Big Data World with enormous amount of pretty fast user friendly software ready for an automatic output of probabilities, nice model figures, and diagrams that may lead to a discovery or, alternatively, mislead to a deceptive conclusion, erroneous claims and predictions.

A deceptive conclusion could be avoided by verification of candidate models against reproducible experiments on empirical data and *in no other way*. Self-testing must be done in advance claiming prediction of hazardous areas and/or times. Unfortunately, many alarmists do not care at all about any testing, when spreading their deceptive predictions of extreme catastrophic events. Seismology is not an exception.

Many people, including scientists, do not distinguish between 'unpredictable,' 'random,' and 'haphazard,' which distinction is crucial for scientific reasoning and conclusions.

Boissonnade and Shah (1984) noted: "However, ignorance still exists on the seismic severity (usually expressed in intensity values) a site may expect in the future as well on the damage a structure may sustain for a given seismic intensity".

Regretfully, this applies to the present day situation in analyzing potential damages and losses for implementation of integrated economic, structural, legal, social, health, cultural, educational, environmental, technological, political, and institutional measures.

« *SCIENCE SHOULD be able to warn people of looming disaster*, Vladimir Keilis-Borok believes.
“My main trouble,” he says, “is feeling of responsibility.”»
(*Los Angeles Times*, 9 July 2012)

Even the advanced tools of data analysis may lead to wrong assessments when inappropriately used to describe the phenomenon under study. A (self-) deceptive conclusion could be avoided by verification of candidate models in experiments on empirical data and in no other way. Seismology is not an exception.

Vladimir Isaacovich KEILIS-BOROK (1921-2013)

Earthquake forecast/prediction

Earthquake prediction is an uncertain profession. Many methods for earthquake forecast/prediction have been proposed and some of these methods may be reliable. Some of those might be even useful in mitigating seismic risks and reducing losses due to catastrophic earthquakes and associated phenomena. For a reliable earthquake claim one must be knowledgeable in understanding seismic effects.

Earthquake forecast/prediction is usually defined as specifying the time, place, and magnitude of an anticipated event with sufficient precision that allow for actions to reduce loss of life and damage to property, as well as to mitigate disruption to life lines and social fabric. Some distinguish forecasting as prediction supplemented with probability of occurrence (Allen, 1976; National Research Council, 1976). In common everyday language, however, "forecast" and "prediction" are synonymous to the public when they are referring to earthquake phenomenon.

Prediction of time and location of an earthquake of a certain magnitude range can be classified as follows -

- **Term-less prediction of areas prone to earthquakes of certain magnitude**
- **Prediction of time and location of an earthquake of certain magnitude**

Temporal, ***in years***		Spatial, ***in source zone size L***	
Long-term	10	Long-range	up to 100
Intermediate-term	1	Middle-range	5-10
Short-term	0.01-0.1	Narrow	2-3
Immediate	0.001	Exact	1

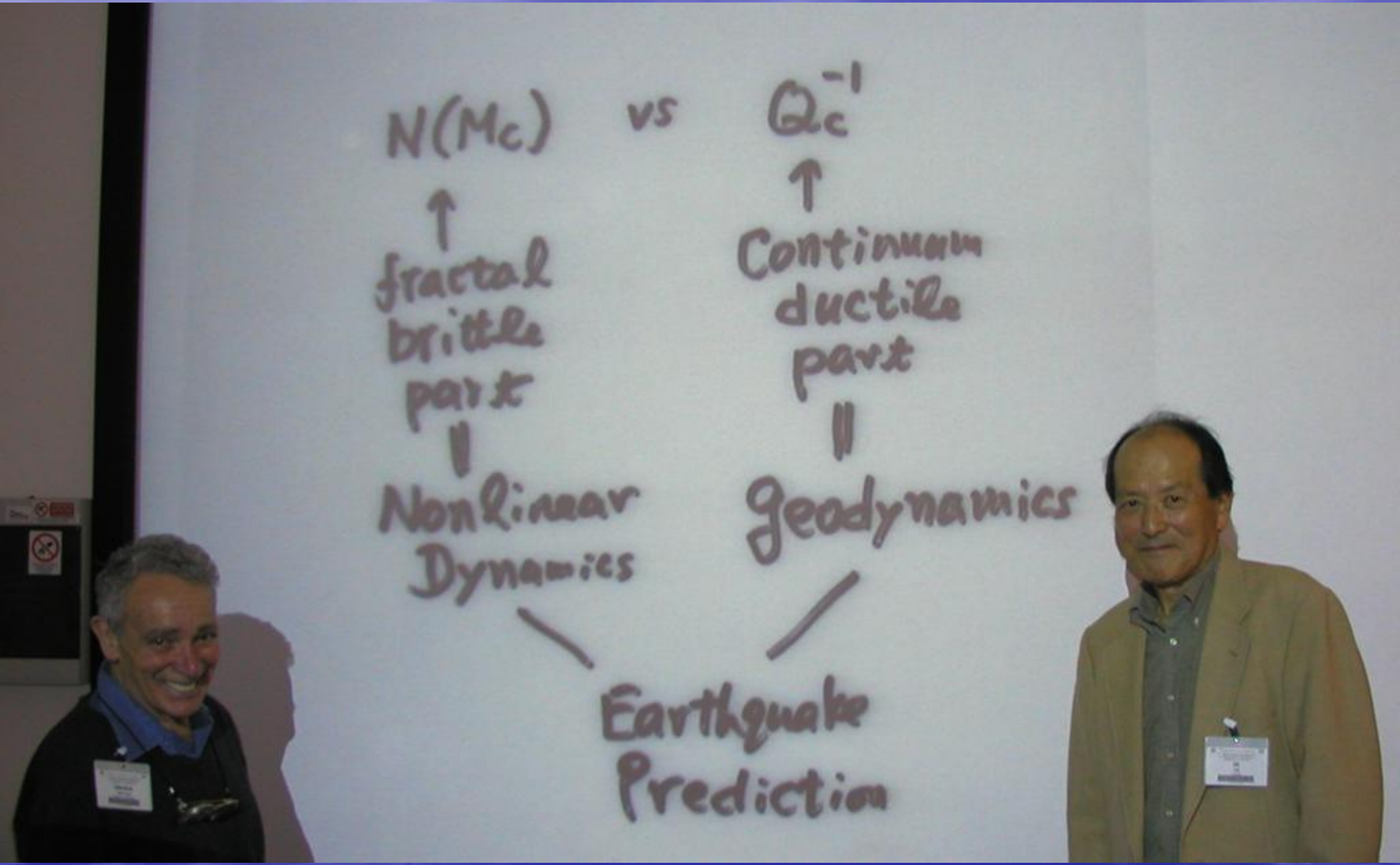
- **The Gutenberg-Richter law suggests limiting magnitude range of prediction to about one unit of magnitude.**

Otherwise, the statistics would be essentially related to dominating smallest earthquakes.

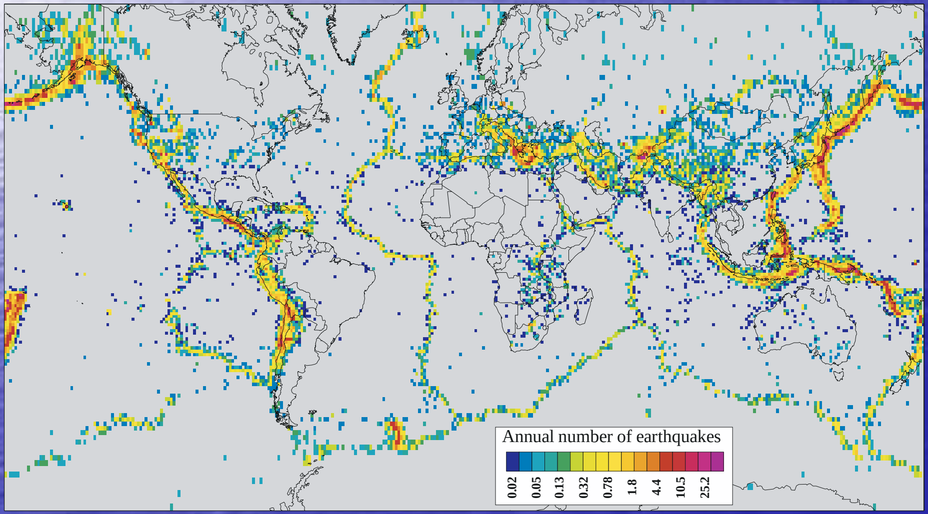
“Что нам известно о землетрясениях?

Землетрясения настолько сложны, что необходимо пользоваться Статистикой…”

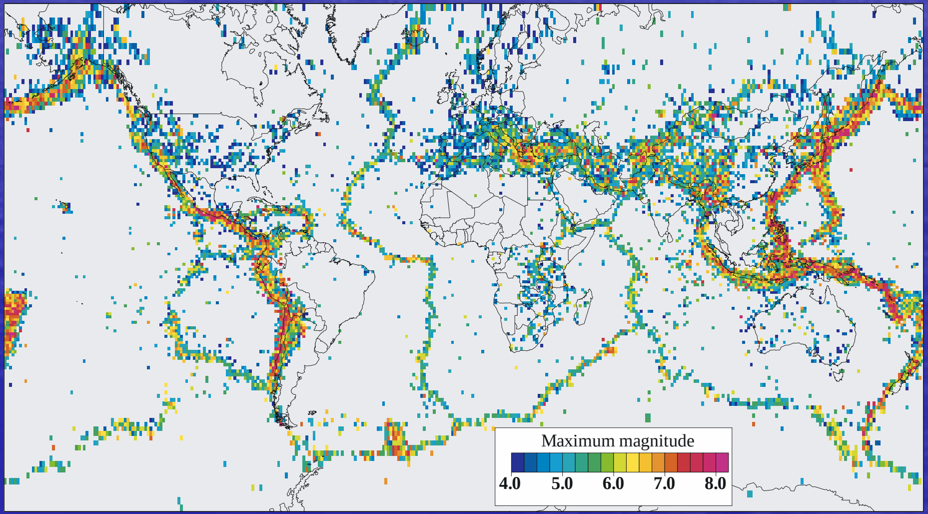
Keiiti Aki (1930-2005)


N(Mc) vs Q_c^{-1}
fractal
brittle
part
Continuum
ductile
part
Nonlinear
Dynamics
Geodynamics
Earthquake
Prediction

A high level of the spatial predictability of earthquakes is evident. **The boundaries of the tectonic plates are clearly defined. Seismicity is particularly intense in subduction zones, a broad band of seismicity extends from Southern Europe to Southeast Asia, which is associated with collision zones between the Eurasian plate and the African, Arabian, and Indian plates. The range of the annual average number of M 4.0 or larger earthquakes in nonempty 1°×1° cells is more than three decimal orders.**



M 4 or larger during the period 1964–1995



Mmax in a 1°×1° cell in the period 1900–1997

Kossobokov, V.G., Keilis-Borok, V.I., Turcotte, D.L., Malamud, B.D.: Implications of a statistical physics approach for earthquake hazard assessment and forecasting. Pure Appl. Geophys., 157: 2323-2349 (2000). https://doi.org/10.1007/PL00001086

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Vol.97, December 2021, pp.1514-1519

Testing Earthquake Prediction Algorithms

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[!]*Passed away on 23rd of September, 2021*
***E-mail:** volodya@mitp.ru*

ABSTRACT

The problem of estimating efficiency and comparing different earthquake prediction algorithms remains pivotal for operational decision making and reducing losses from earthquakes. Healy et al. (1992) considered this problem in terms of strict mathematical analysis of the prediction outcomes in the design of Global Testing of the algorithm M8. For 30 years now, every six months, this earthquake prediction algorithm has been applied globally, determining in real time the areas in which the World's largest earthquakes are most likely to occur in the current half-year. To date, the statistics of the results obtained in this Global Test indicates, with reliability higher than 99%, a fairly high efficiency of forecasts using the M8 algorithm, as well as in its combination with the MSc algorithm, which specifies the localization of the source zone of the expected earthquake. Thus, the null hypothesis of random occurrence in seismically active regions is rejected with seismological certainty, at least for the World's largest earthquakes. The results of this experimental testing are an indirect confirmation of the predictability of strong earthquakes, as well as the existence of common dynamic characteristics and diverse behavior during phase transitions in a complex hierarchical nonlinear system of faults-and-blocks of the Earth's lithosphere (Keilis-Borok, 1990).

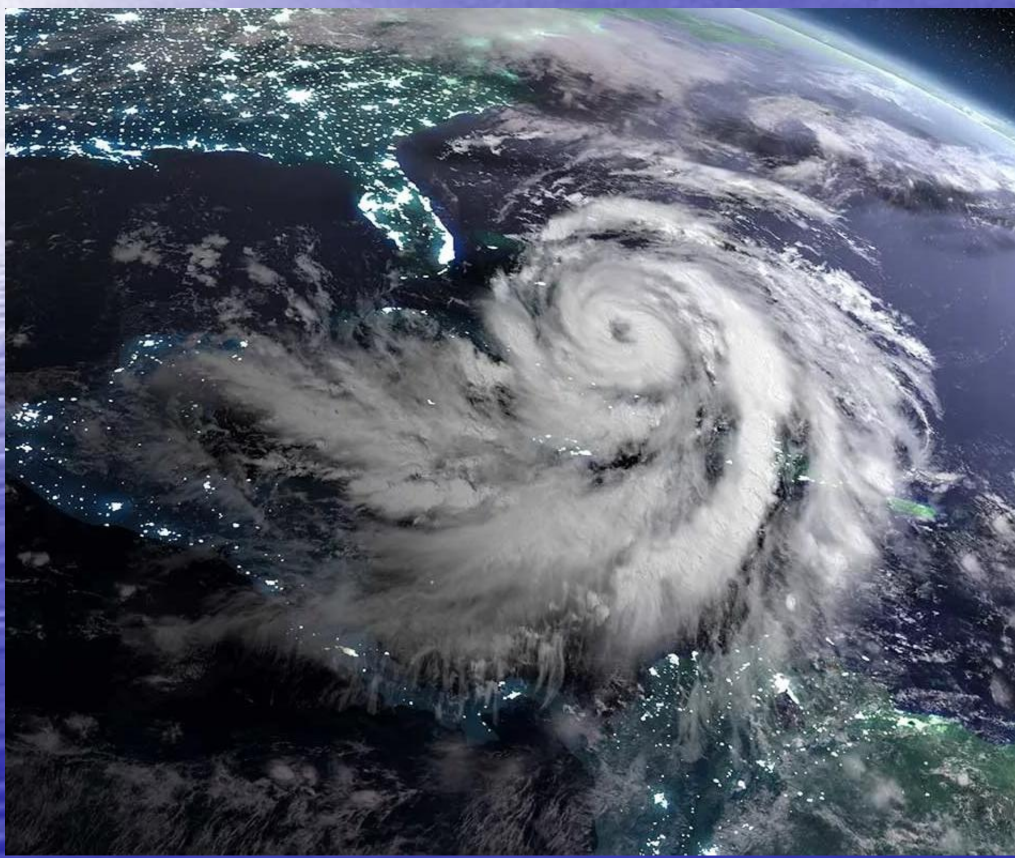
delicate application of statistics. Regretfully, in many cases the claims of a high potential of the algorithm are based on a flawed application of Statistics and, therefore, are hardly suitable for communication to decision makers. Making prediction claims, either timeless or time dependent, quantitatively probabilistic in the frames of the most popular objectivists' viewpoint on Probability requires a long series of "yes/no" trials, which cannot be obtained without an extended rigorous testing of the method predictions against real observations. Moreover, as pointed out by Stark (2017) the distinction between 'random,' 'haphazard,' and 'unpredictable' is crucial for scientific inference and applications in practice.

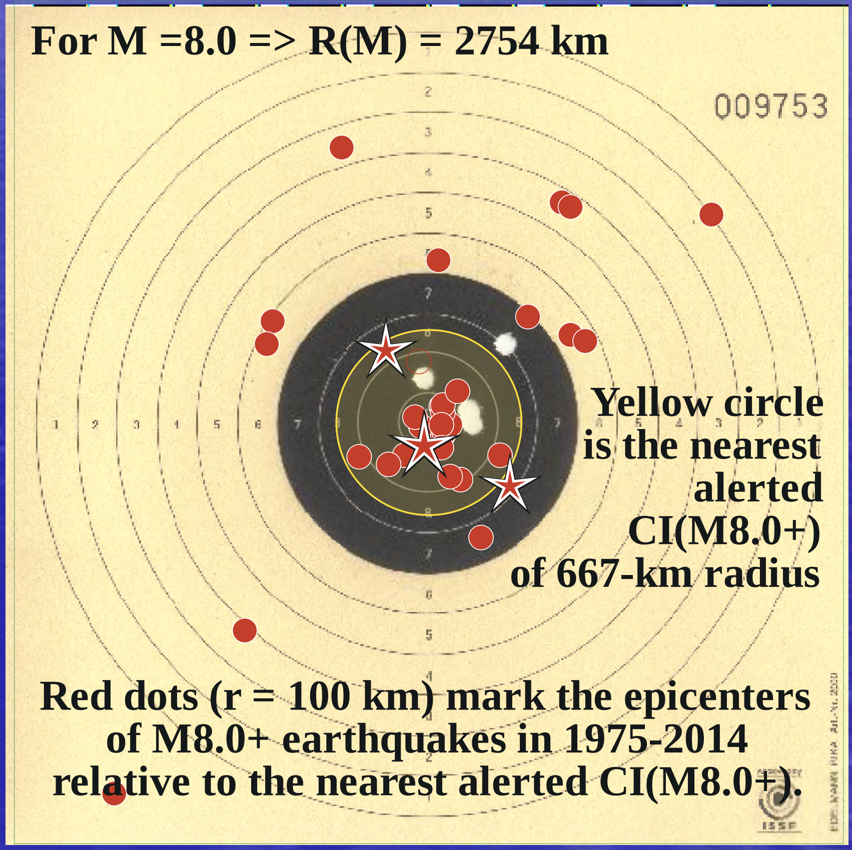
Generally speaking, this immediately implies a very small sample of cases investigated by delicate statistical methods applied to the data of different quality collected in different conditions. Many extreme events are correlated and/or grouped, are apparently not independent, and follow some "strange" distribution, e.g., like a mono- or multifractal one which is barely homogeneous. Obviously, such a "peculiar" situation complicates search and identification of precursory behavior for forecast/prediction purposes.

Earthquake prediction is an uncertain profession. Many methods have been proposed for forecasting the earthquakes and, perhaps, some of these methods may prove to be reliable. Some may even be useful for reducing seismic risks and losses from earthquakes and associated secondary effects like tsunami, landslides, liquefaction, floods, fires

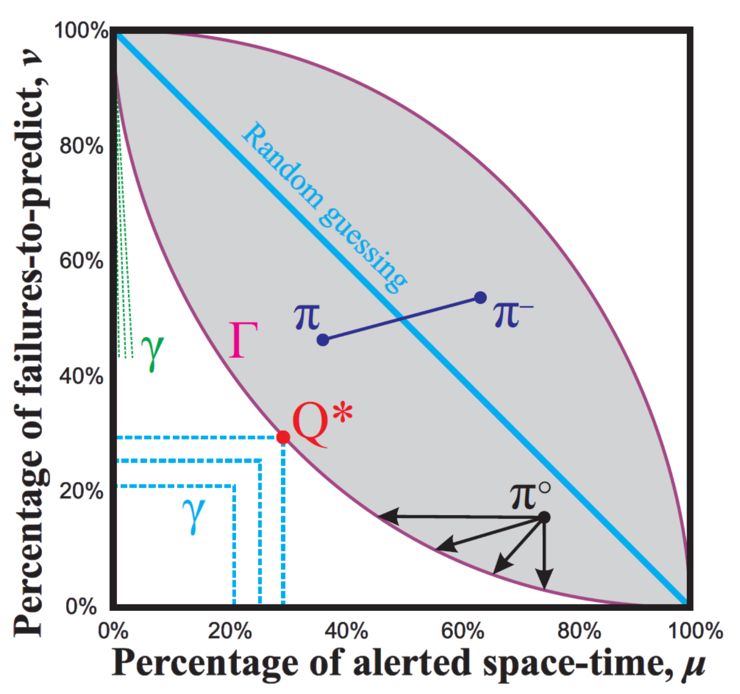
One may compare the intermediate-term accuracy of earthquake prediction in time to the next day warning of a coming hurricane, while the middle-range accuracy in location to shooting 8 or more points by an air-pistol from 10 m. This kind of accuracy is proved achievable and reliable in 30 years of rigid real-time testing the M8 algorithm.

Level of the temporal predictability of earthquakes





Self-testing must be done in advance claiming prediction of hazardous areas and/or times. It is evident the necessity and possibility of applying simple tools of Earthquake Prediction Strategies, in particular, *Error Diagram* and *Seismic Roulette null-hypothesis* as a metric of the alerted space.



Error Diagram: Γ curve for finding optimal strategies.

Optimal strategy for a given loss function γ, corresponds to the best choice of costs-and-benefits at point Q* where the γ-contour lines (dashed lines) touch the error set for all possible prediction strategies based on a fixed limited knowledge (grey area) for the first time. Random guess diagonal connects the trivial extremes of optimistic and pessimistic strategies.

It should be noted that Error Diagram by Molchan (1997) was designed from the standpoint of decision making theory especially for finding the optimal earthquake prediction strategy, while its analog the Receiver Operating Characteristic curve - ROC curve, originally developed for operators of military radar receivers starting in 1941. The optimal prediction strategy depends on a choice of cost-benefit function and allows for mixed use of different strategies, as well as the antipodal one.

Molchan, G.M. (1997) Earthquake prediction as a decision-making problem. Pure and Applied Geophysics 149, 233–247. https://doi.org/10.1007/BF00945169
Molchan, G.M. (2003) Earthquake Prediction Strategies: A Theoretical Analysis. In: Keilis-Borok V.I., Soloviev A.A. (eds) Nonlinear Dynamics of the Lithosphere and Earthquake Prediction. Springer Series in Synergetics, Springer, Berlin, Heidelberg, Germany, 209-237. https://doi.org/10.1007/978-3-662-05298-3_5

Seismic Roulette null hypothesis

Are the results of the prediction experiment "good" or not? A statistical conclusion about that could be attributed in the following general way:

Let $\mathfrak{T}$ and $\mathfrak{S}$ be the total time and territory considered; $\mathfrak{A}_t$ is the territory covered by the alarms at time t; $\tau \times \mu$ is a measure on $\mathfrak{T} \times \mathfrak{S}$ (we consider a direct product measure $\tau \times \mu$ reserving more general case of a time-space dependent measure ζ for future more sophisticated null-hypotheses); N counts the total number of earthquakes in range $Mm+$ within $\mathfrak{T} \times \mathfrak{S}$, and n counts how many of them are predicted. The time-space occupied by alarms, in percentage to the total space-time considered equals

$$p = \int_{\mathfrak{A}} d(\tau \times \mu) \Big/ \int_{\mathfrak{T}\times\mathfrak{S}} d(\tau \times \mu)$$

where $\mathfrak{A}$ is the union of all the alerted territories $\mathfrak{A}_t$ in $\mathfrak{T} \times \mathfrak{S}$ considered.

By common definition the statistical significance level of the prediction results equals $\alpha = 1 - \mathbf{B}(n - 1, N, p)$, where $\mathbf{B}$ is the cumulative binomial distribution function. The smaller is the significance level α, the larger is the confidence level $1 - \alpha$ and the higher is the significance of the predictions under testing.

A practical recipe of using μ-measure in assessing statistical significance of an earthquake prediction method is as easy as i, ii, iii: (i) take a reliable sample catalog of earthquakes and count how many events from it are inside the territory considered – this will be your denominator; (ii) at a given time of regular prediction updates, count how many events from the catalog are inside the area of alarm – this will be your numerator; (iii) integrate the ratio over the time of prediction experiment – the result is an estimate of $\boldsymbol{p}$ to be used with the achieved predicted n versus total N target earthquakes in computing the significance of the method predictions.

Consider a roulette wheel with as many pockets as the number of events in a sample catalog of earthquakes, a pocket for each event.

- Make your bet according to prediction: determine, which events are inside area of alarm, and put one chip in each of the corresponding pockets.
- Nature turns the wheel.
- If seismic roulette is not perfect…

then ***systematically*** you can win! ☺

or lose … ☹

If you are smart enough to know "antipodal strategy" (Molchan, 1994; 2003), make the predictions efficient - and your wins will outscore the losses! ☺

☺ ☹ ☺ ☺ ☺ ☹ ☺ ☺ ☺

Note that earthquake related observations are limited to the recent most decades or centuries in just a few rare cases.

Getting, experimentally, reasonable confidence limits on an objective estimate of recurrence rate of an earthquake requires a geologic span of time which is unreachable for instrumental, or even historical, seismology (see, e.g., *Beauval et al., 2008***). That is why**

Probability estimates by Probabilistic Seismic Hazard Analysis remain subjective values ranging from 0 to 1,

derived from analytically tractable hypothetical models of seismicity.

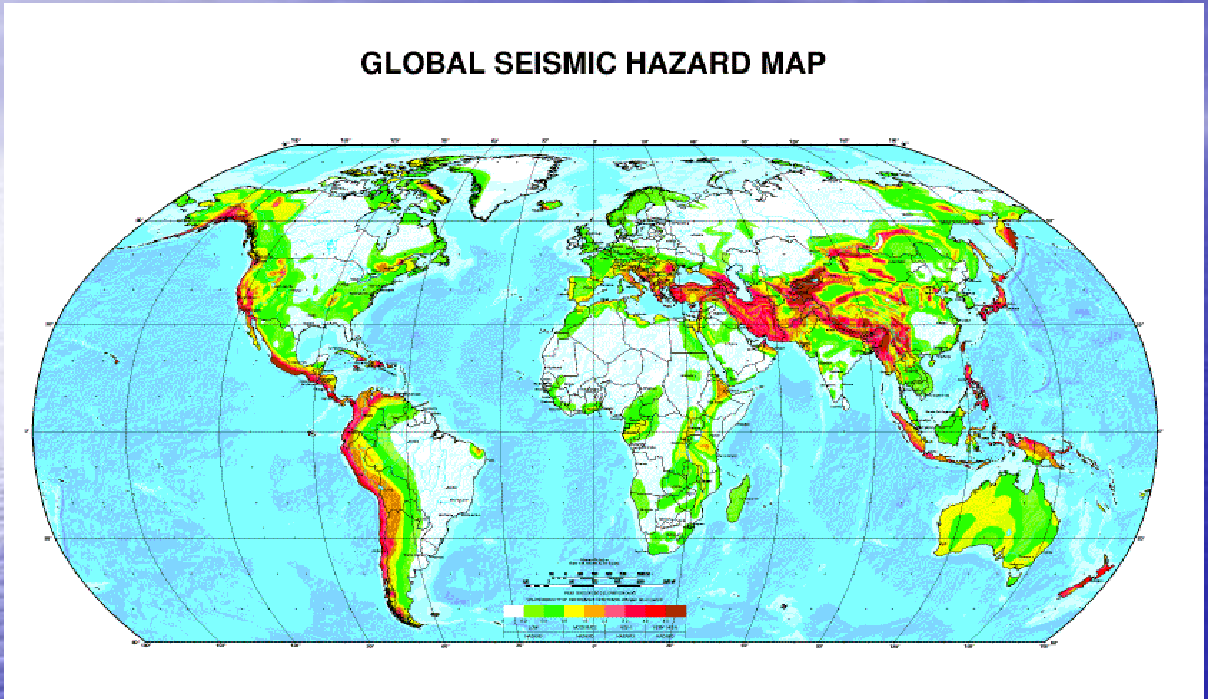
Making SHA claims, either termless or time dependent (t-DASH), quantitatively probabilistic in the frames of the most popular objectivists' viewpoint on probability requires a long series of "yes/no" trials, which cannot be obtained without an extended rigorous testing of the method predictions against real observations.

Note that *the effectiveness of any method can be established in no other way but testing*

The set of errors, i.e. the rates of failure and of the alerted space-time volume, can be easily compared to random guessing, which comparison permits evaluating the SHA method effectiveness and determining the optimal choice of parameters in regard to a given cost-benefit function. These and other information obtained in such a simple testing may supply us with a realistic estimates of confidence and accuracy of SHA predictions and, if reliable but not necessarily perfect, with related recommendations on the level of risks for decision making in regard to engineering design, insurance, and emergency management.

The examples of independent expertize of "seismic hazard maps", "precursors", and "forecast/prediction methods" to follow:

"One is well advised, when traveling to a new territory, to take a good map and then to check the map with the actual territory during the journey" [Wasserburg, 2010].



The Global Seismic Hazard Assessment Program (GSHAP) was launched in 1992 by the International Lithosphere Program (ILP) with the support of the International Council of Scientific Unions (ICSU), and endorsed as a demonstration program in the framework of the United Nations International Decade for Natural Disaster Reduction (UN/IDNDR). The GSHAP project terminated in 1999 .

A systematic comparison of the GSHAP peak ground acceleration estimates with those related to actual strong earthquakes discloses gross inadequacy of this "probabilistic" product, which appears *UNACCEPTABLE FOR ANY KIND OF RESPONSIBLE SEISMIC RISK EVALUATION AND KNOWLEDGEABLE DISASTER PREVENTION.*

- Kossobokov, V.G., 2010. Scaling Laws and Earthquake Predictability in Assessment of Seismic Risk. Advanced Conference on Seismic Risk Mitigation and Sustainable Development. The Abdus Salam International Centre for Theoretical Physics (Trieste - Italy, 10 - 14 May 2010). http://cdsagenda5.ictp.trieste.it/full_display.php?ida=a09145)
- Kossobokov, V. G. ; A. K. Nekrasova, 2010. Global Seismic Hazard Assessment Program Maps Are Misleading. Eos Trans. AGU, 91(52), Fall Meet. Suppl., Abstract U13A-0020.
- Kossobokov, V., Nekrasova, A., 2011. Global Seismic Hazard Assessment Program (GSHAP) Maps Are Misleading. *Problems of Engineering Seismology*, 38 (1), p. 65-76 (in Russian).
- Wyss, M, Nekrasova, A, Kossobokov, V (2012) Errors in expected human losses due to incorrect seismic hazard estimates. Natural Hazards, 62 (3): 927-935; DOI 10.1007/s11069-012-0125-5

Each of 1181 strong crustal earthquakes in 2000-2009 has from 6 to 58 values of GSHAP PGA in the ¼° × (¼ cos ϕ)° cell centered at its epicenter (ϕ, λ).

We count a "surprise" when the observed value, $I_0(M)$, is larger than the GSHAP expected maximum, $I_0(mPGA)$, $\Delta I_0 = I_0(M) - I_0(mPGA) > 0$

We found (i) about 50% of strong earthquakes surprised the GSHAP map (ii) each of the 59 magnitude 7.5 or larger earthquakes in 2000-2009 was a "surprise" for GSHAP Seismic Hazard Map; the minimum of the 59 values of ΔI_0 is 0.6. The average and the median of ΔI_0 are about 2.

INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy

Kossobokov, VG, Nekrasova, AK (2012) Global Seismic Hazard Assessment Program Maps are Erroneous. *Seismic Instruments* **48** (2): 162-170; https://doi.org/10.3103/S0747923912020065

Top Twelve Deadliest Earthquakes, 2000-2011

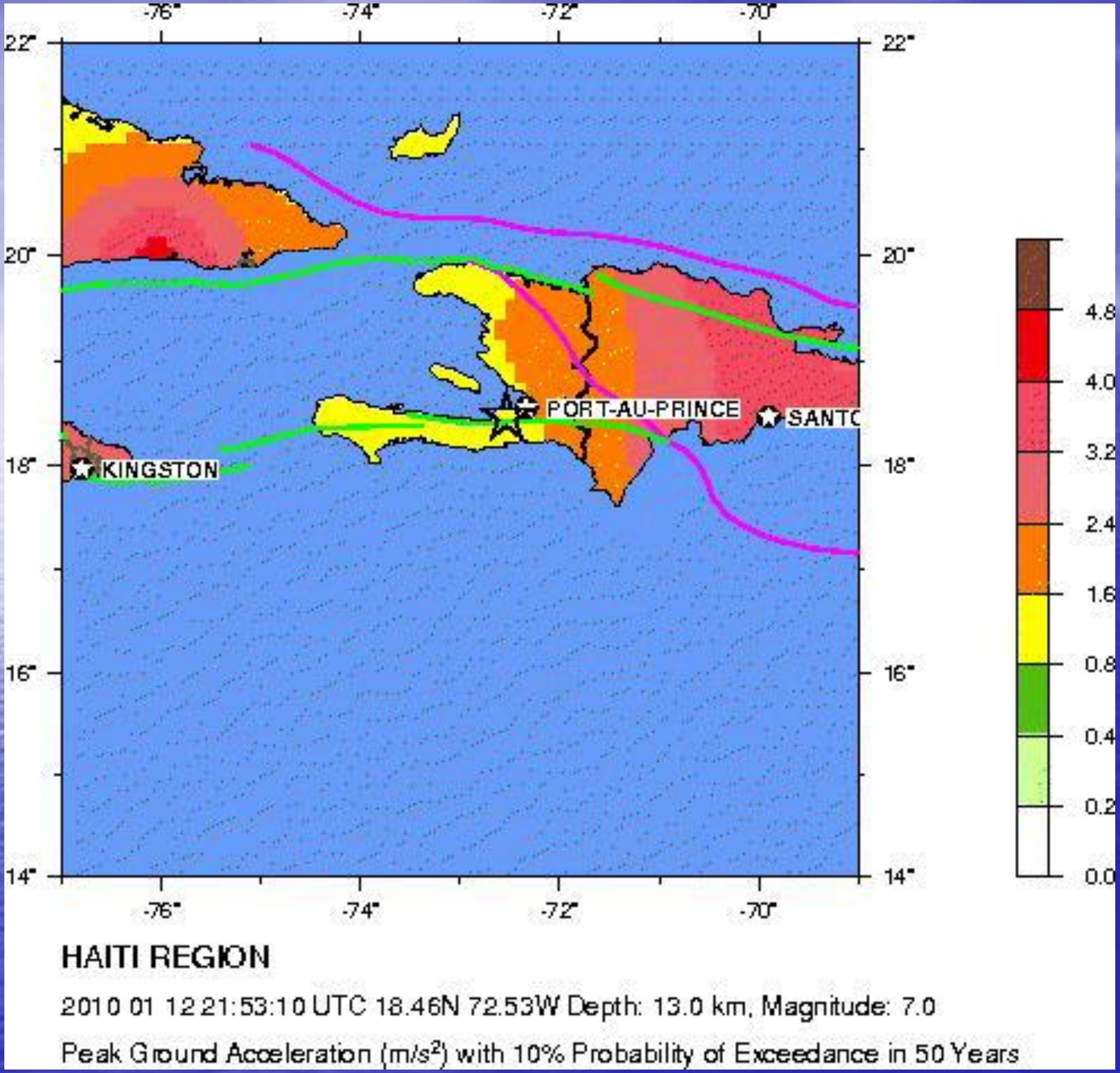
Region	Date	*M*	Fatalities	ΔI_0
Sumatra-Andaman "Indian Ocean Disaster"	26.12.2004	9.0	227898	4.0
Port-au-Prince (Haiti)	12.01.2010	7.3	222570	[illegible]
Wenchuan (Sichuan, China)	12.05.2008	8.1	87587	[illegible]
Kashmir (North India and Pakistan border region)	08.10.2005	[illegible]	[illegible]	[illegible]
Bam (Iran)	[illegible]	[illegible]	[illegible]	[illegible]
Bhuj (Gujarat [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Off th[illegible]	[illegible]	[illegible]	[illegible] missing)	3.2
[illegible]	[illegible]	6.3	5749	0.3
[illegible]	[illegible].04.2010	7.0	2698	2.1
[illegible]ia)	21.05.2003	6.8	2266	2.1
[illegible]matra, Indonesia)	28.03.2005	8.6	1313	3.3
Padang (Southern Sumatra, Indonesia)	30.09.2009	7.5	1117	1.8

M 7.5 - 78km N of Palu, Indonesia 2018-09-28 10:02:43 UTC

0.178°S 119.840°E 10.0 km depth;

ΔI_0 is about 2 or larger.

Fatalities - at least 2,100 people, **the deadliest earthquake in 2018**.



The Global Seismic Hazard Assessment Program (GSHAP) was launched in 1992 by the International Lithosphere Program (ILP) with the support of the International Council of Scientific Unions (ICSU), and endorsed as a demonstration program in the framework of the United Nations International Decade for Natural Disaster Reduction (UN/IDNDR). The GSHAP project terminated in 1999 .

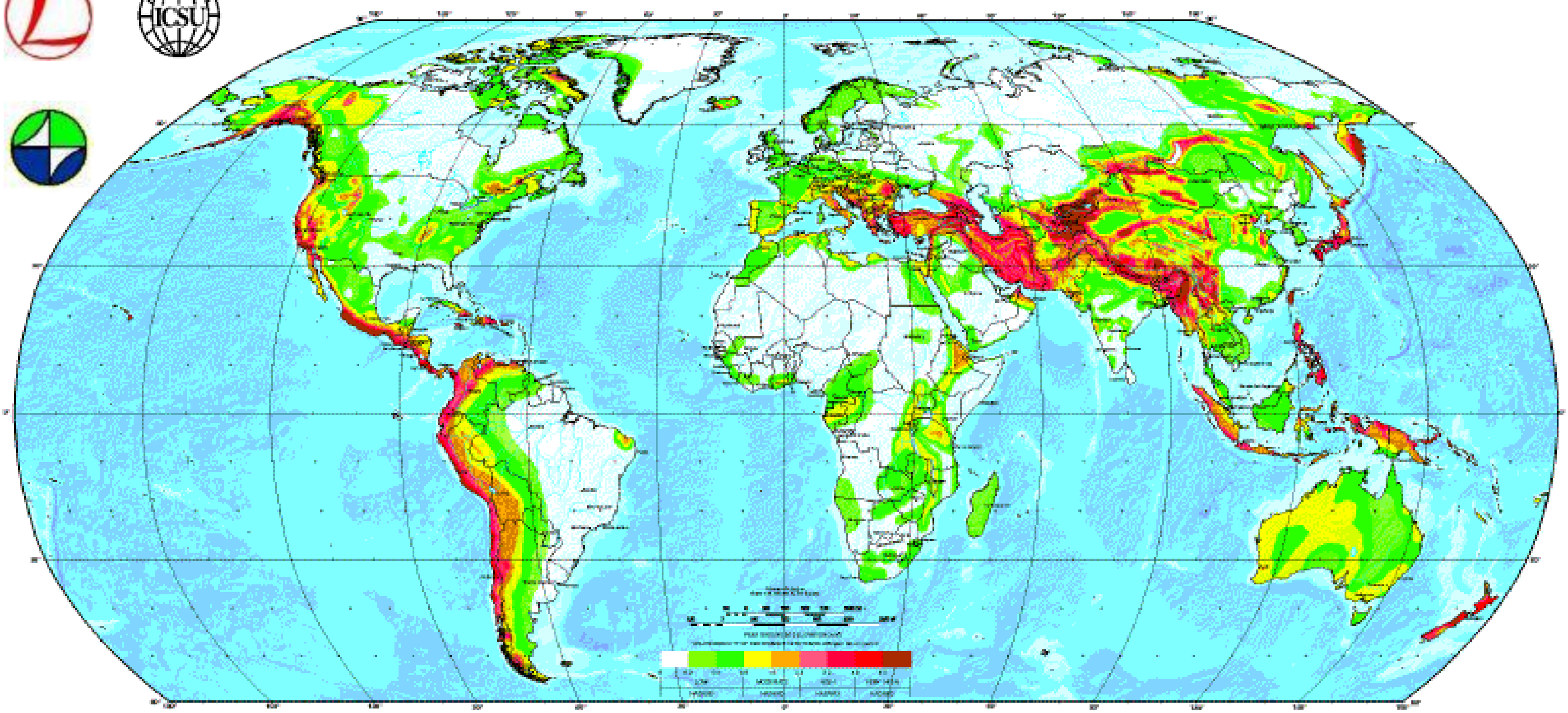
…**рекомендованная как демонстрационная программа** в рамках Международной декады сокращения стихийных бедствий ООН

International Decade for Natural Disaster Reduction
IDNDR
1990 – 2000

GLOBAL SEISMIC HAZARD MAP

UNESCO

ICSU



GeoForschungsZentrum Potsdam

USGS
science for a changing world

ETH

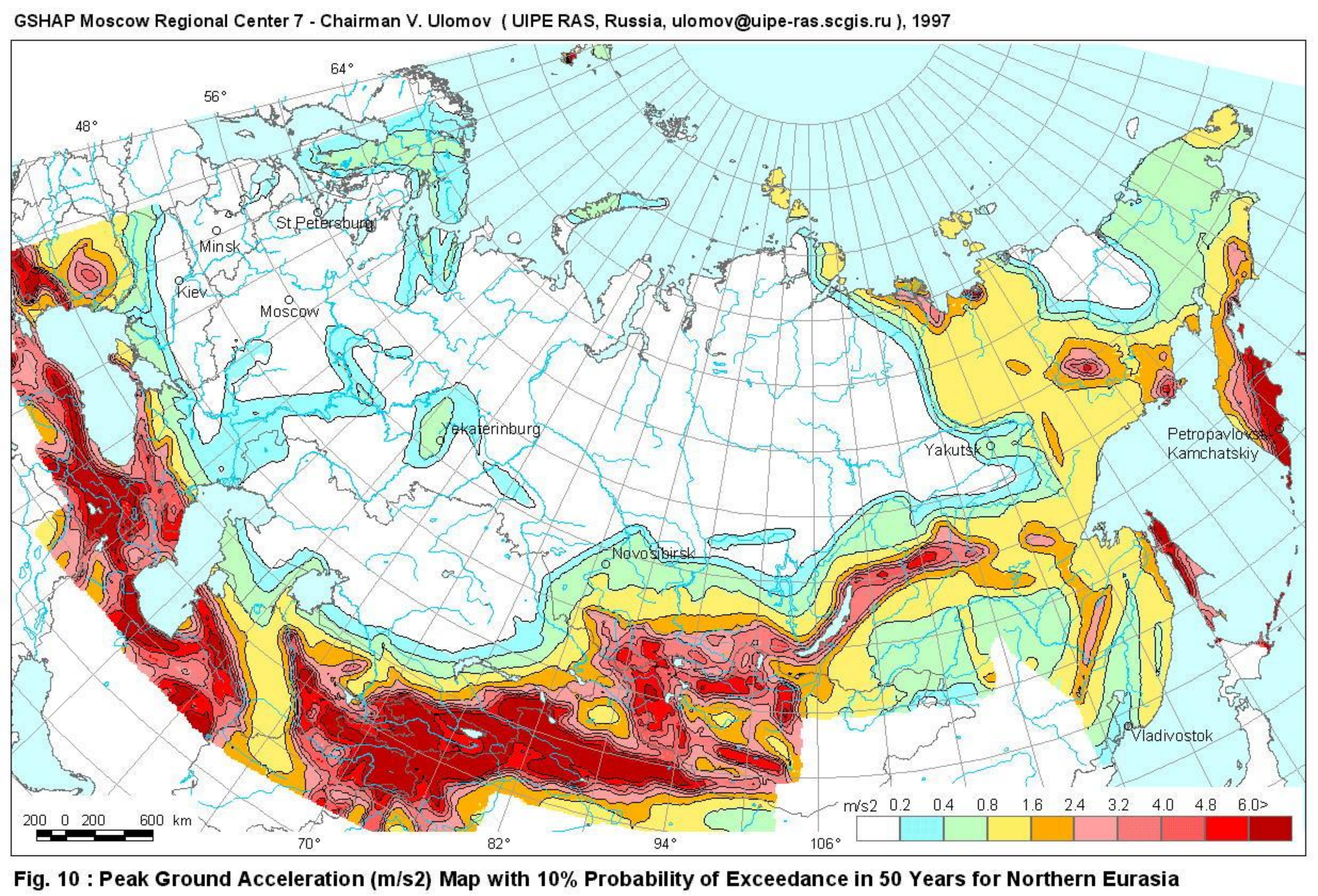
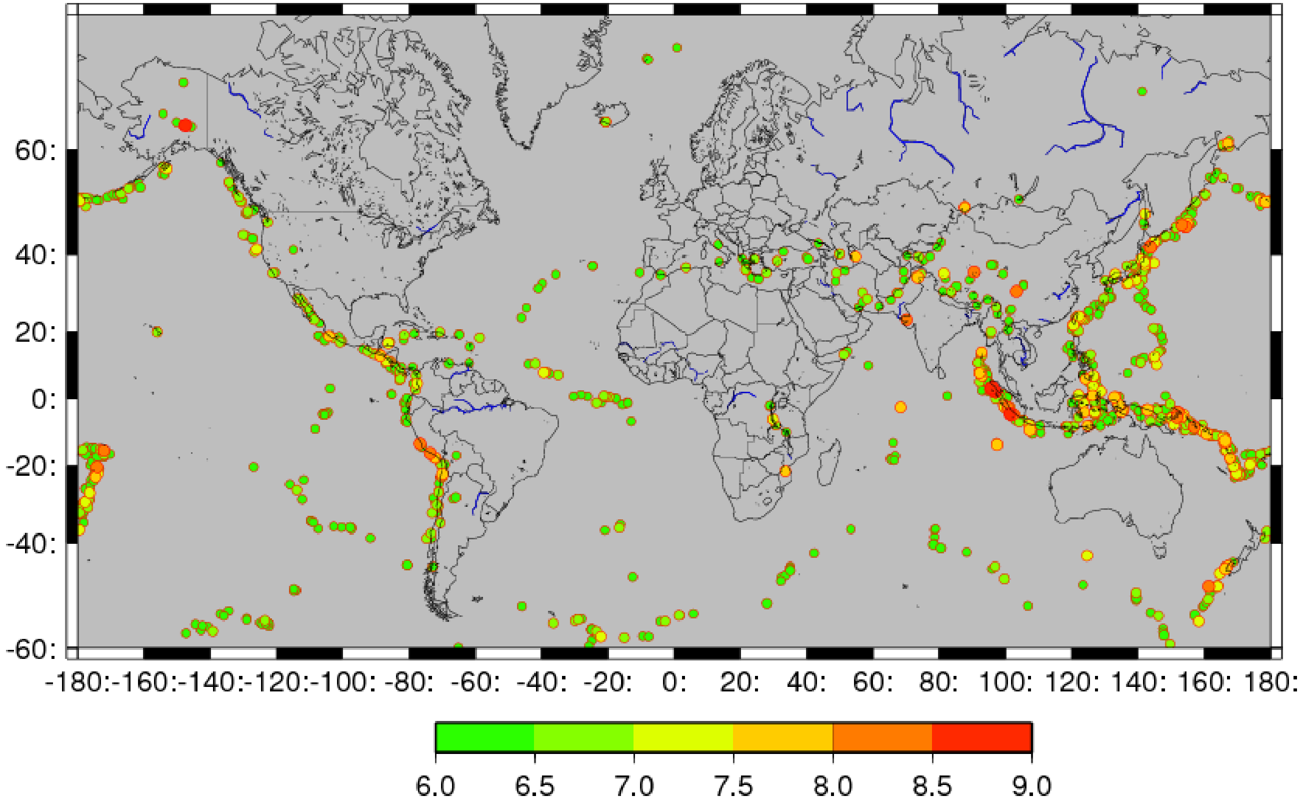


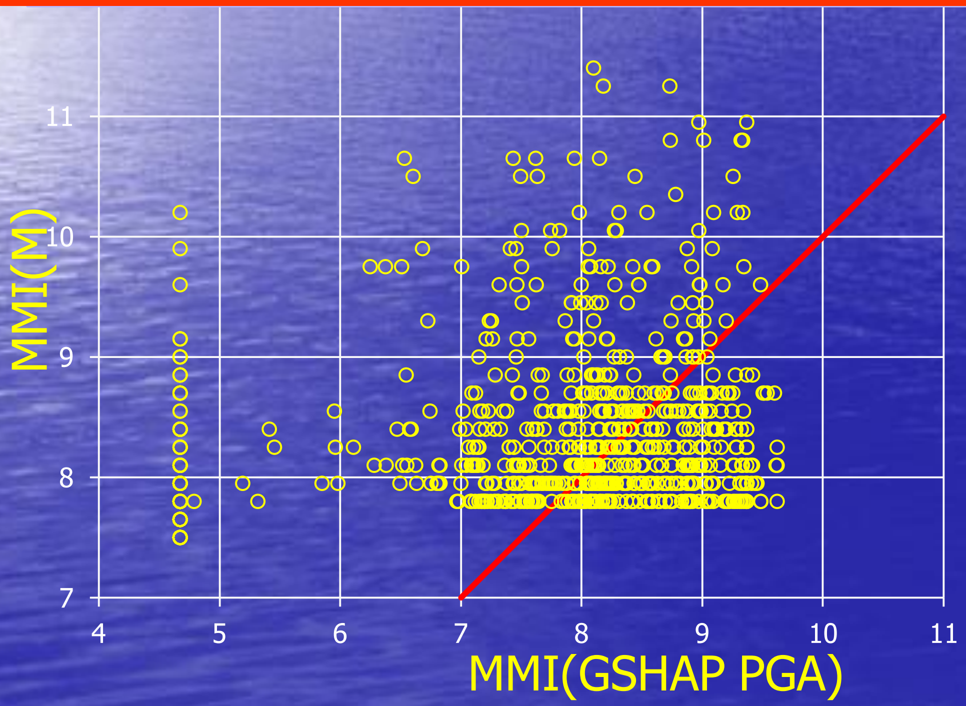
Fig. 10 : Peak Ground Acceleration (m/s2) Map with 10% Probability of Exceedance in 50 Years for Northern Eurasia

После завершения GSHAP сейсмическая реальность тестировала Карту сейсмической опасности

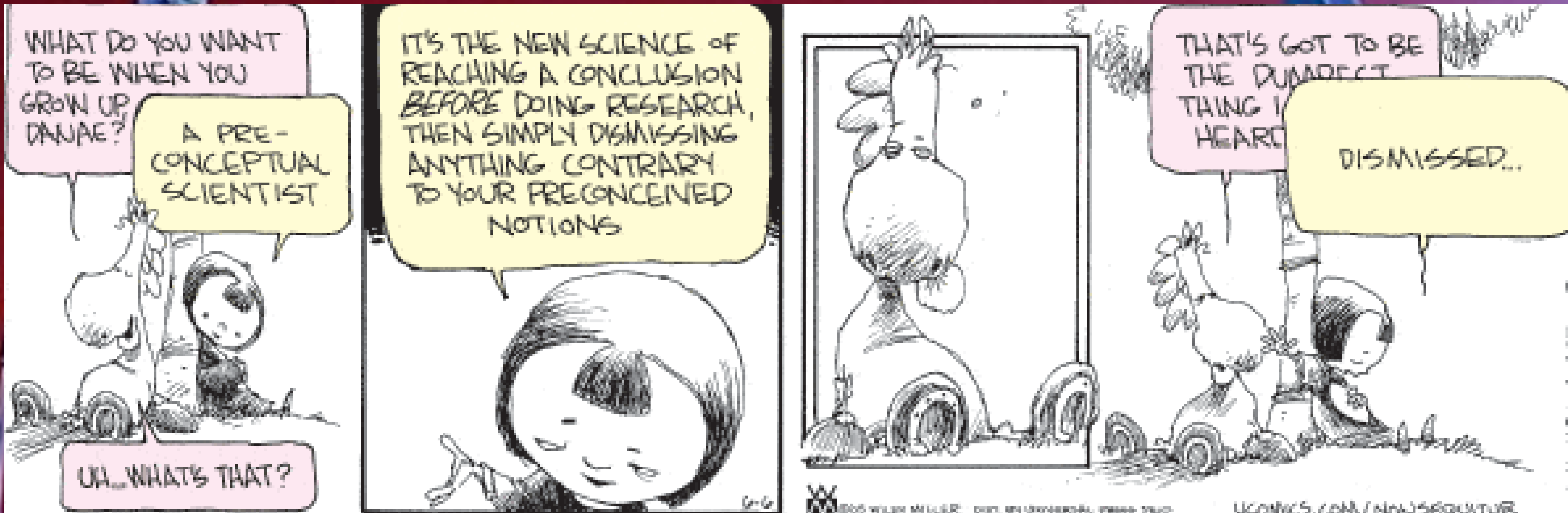


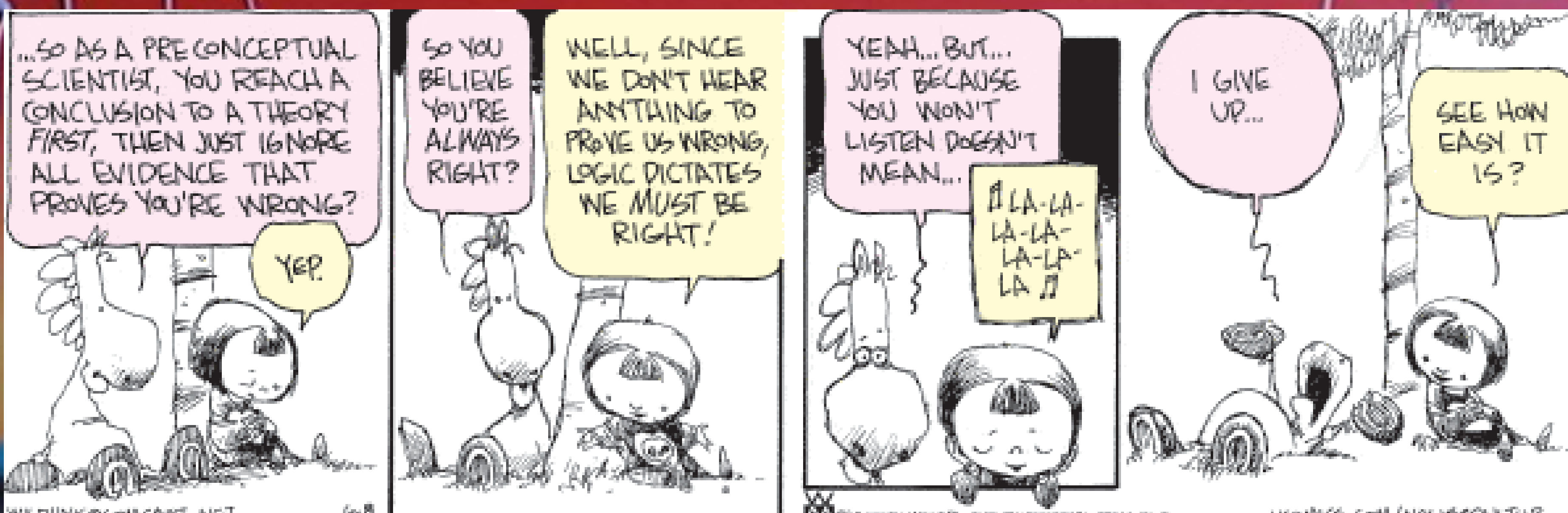
USGS/NEIC Global Hypocenter's Data Base, 2000-2010

Вывод: Карта GSHAP PGA таит в себе обилие «ловушек», где ожидаются «легкие», а в действительности возможны «существенные», «значительные», или даже «тотальные» разрушения. Это относится к каждому второму значительному землетрясению (M = 7.5 и выше).



По статистике точек над диагональю) получим набор оценок числа «сюрпризов». Например, для событий с магнитудой 7.5 и выше средняя недооценка = **1.6**, а её медиана = **2.5 балла.**


WHAT DO YOU WANT TO BE WHEN YOU GROW UP, DANAE?
A PRE-CONCEPTUAL SCIENTIST
UH...WHAT'S THAT?
IT'S THE NEW SCIENCE OF REACHING A CONCLUSION *BEFORE* DOING RESEARCH, THEN SIMPLY DISMISSING ANYTHING CONTRARY TO YOUR PRECONCEIVED NOTIONS
6-6
THAT'S GOT TO BE THE DUMBEST THING I'VE HEARD
DISMISSED...
UCOMICS.COM/NONSEQUITUR
WILEYINK@COMCAST.NET


...SO AS A PRECONCEPTUAL SCIENTIST, YOU REACH A CONCLUSION TO A THEORY *FIRST*, THEN JUST IGNORE ALL EVIDENCE THAT PROVES YOU'RE WRONG?
YEP.
SO YOU BELIEVE YOU'RE ALWAYS RIGHT?
WELL, SINCE WE DON'T HEAR ANYTHING TO PROVE US WRONG, LOGIC DICTATES WE *MUST* BE RIGHT!
YEAH...BUT... JUST BECAUSE YOU WON'T LISTEN DOESN'T MEAN...
♫ LA-LA-LA-LA-LA-LA-LA ♫
I GIVE UP...
SEE HOW EASY IT IS?
WILEYINK@COMCAST.NET
6-8
UCOMICS.COM/NONSEQUITUR

Kossobokov V., Peresan A., Panza G.F. (2015)

Reality Check: Seismic Hazard Models You Can Trust. **EOS 96(13): 9-11**

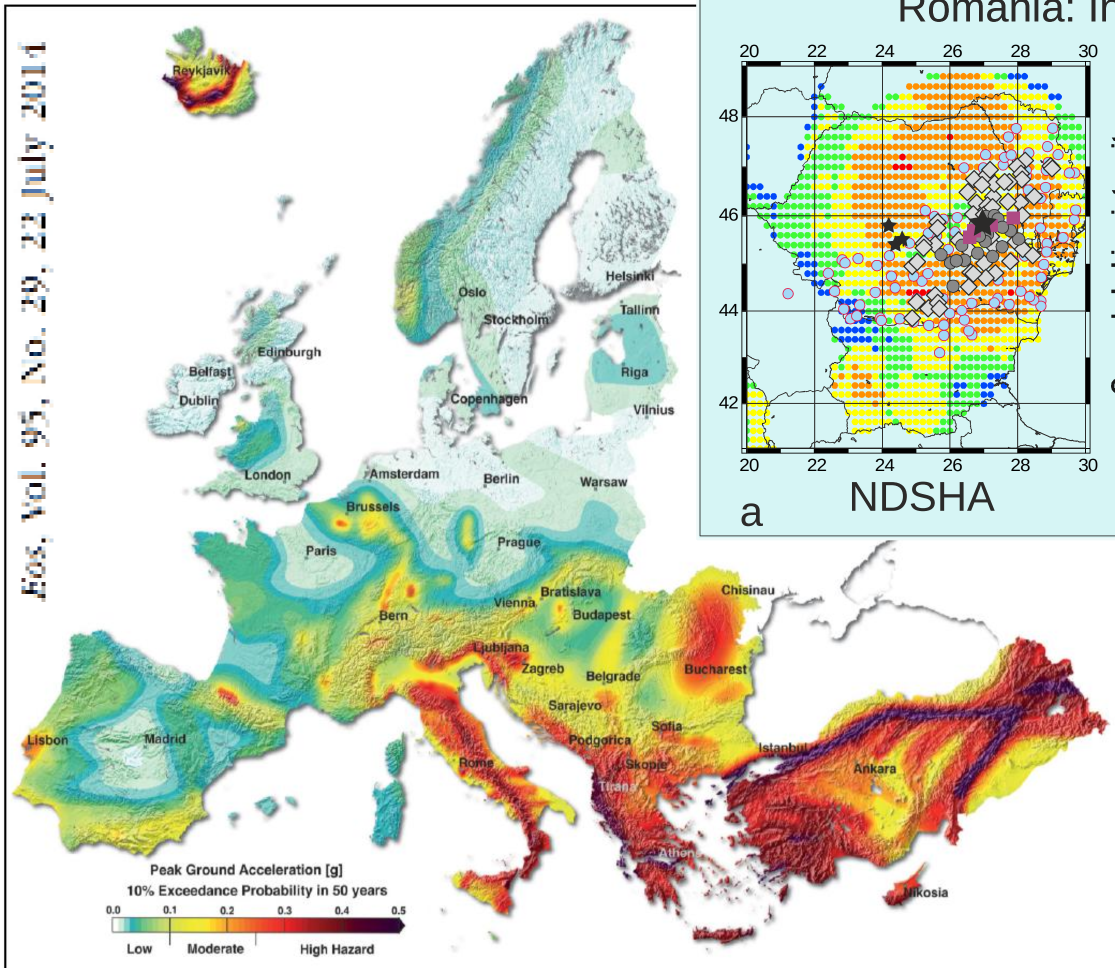
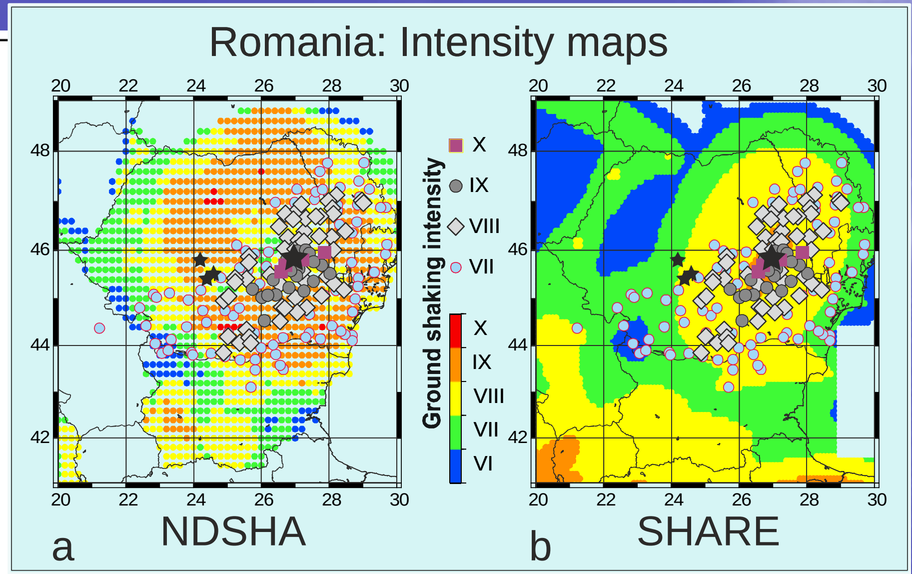
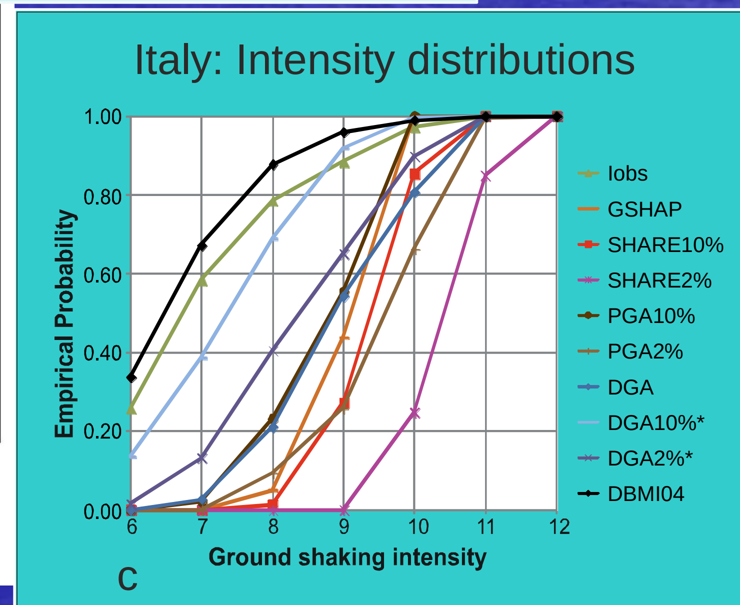


Fig. 1. European Seismic Hazard Map (ESHM13) displaying the 10% exceedance probability in 50 years for peak ground acceleration (PGA) in units of gravity (g). Cold colors indicate comparatively low hazard areas (PGA ≤ 0.1g), yellow and orange indicate moderate-hazard values (0.1g < PGA ≤ 0.25g), and red colors indicate high-hazard areas (PGA ≥ 0.25g).



★ - the epicenters of the 1940 M 7.7 Vrancea and 1550, 1571, 1590 violent shocks in Fagaras zone



Chapter 12

Why are the Standard Probabilistic Methods of Estimating Seismic Hazard and Risks Too Often Wrong

Giuliano Panza[1,2,3,6], Vladimir G. Kossobokov[2,4,5,6], Antonella Peresan[1,2,6] and Anastasia Nekrasova[2,4]

[1] *Department of Geosciences, University of Trieste, Trieste, Italy,* [2] *The Abdus Salam International Centre for Theoretical Physics — SAND Group, Trieste, Italy,* [3] *China Earthquake Administration, Institute of Geophysics, Beijing, China,* [4] *Institute of Earthquake Prediction Theory and Mathematical Geophysics, Russian Academy of Sciences, Moscow, Russian Federation,* [5] *Institut de Physique du Globe de Paris, France,* [6] *International Seismic Safety Organization, ISSO*

Ne quid falsi dicere audeat, ne quid veri non audeat

De oratore II, 15, 62 (Cic)

ABSTRACT

According to the probabilistic seismic hazard analysis (PSHA) approach, the deterministically evaluated or historically defined largest credible earthquakes (often referred to as Maximum Credible Earthquakes, MCEs) are "an unconvincing possibility" and are treated as "likely impossibilities" within individual seismic zones. However, globally over the last decade such events keep occurring where PSHA predicted seismic hazard to be low. Systematic comparison of the observed ground shaking with the expected one reported by the Global Seismic Hazard Assessment Program (GSHAP) maps discloses gross underestimation worldwide. Several inconsistencies with available observation are found also for national scale PSHA maps (including Italy), developed using updated data sets. As a result, the expected numbers of fatalities in recent disastrous earthquakes have been underestimated by these maps by approximately two to three orders of magnitude. The total death toll in 2000–2011 (which exceeds 700,000 people, including tsunami victims) calls for a critical reappraisal of GSHAP results, as well as of the underlying methods.

In this chapter, we discuss the limits in the formulation and use of PSHA, addressing some theoretical and practical issues of seismic hazard assessment, which range from the overly simplified assumption that one could reduce the tensor problem of seismic-wave generation and propagation into a scalar problem (as implied by ground motion

Earthquake Hazard, Risk, and Disasters. http://dx.doi.org/10.1016/B978-0-12-394848-9.00012-2
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A simple answer exists to the question in the title of this chapter: most, if not all, the standard probabilistic methods to assess seismic hazard, namely PSHA, and associated risks are based on subjective, commonly unrealistic, and even erroneous assumptions about seismic recurrence. After years with many publications, we know that *recurrent earthquake hazard results have failed us.*

ON SIMILARITY IN THE SPATIAL DISTRIBUTION OF SEISMICITY

V. G. Kosobokov
International Institute of Earthquake Prediction Theory and Mathematical Geophysics, Russian Academy of Sciences

S. A. Mazhkenov
Presidium of the Kasakh National Academy of Sciences

The basic law of seismicity, the Gutenberg-Richter recurrence relation, is suggested in a modified form involving a spatial term: $\log N(M,L) = A - B(M-5) + C\log L$, where $N(M,L)$ is the expected annual number of mainshocks of a certain magnitude M within an area of linear size L. Using the original algorithm tested on a number of model catalogs, estimates of similarity coefficients, A, B, and C were obtained for seismic regions of FSU and other countries worldwide, as well as for global seismic belts of the Earth. The coefficient C reflects spatial similarity of a set of epicenters. Making appropriate assumptions of homogeneity and self-similarity, it can be referred to as the fractal dimension of the set. The actual values of C vary from 1.0 to 1.5 and correlate with the geometry of tectonic features: High values of C for regions of complex dense patterns of faults of different strikes, and low values of C for regions with a predominant linear fault zone. The coefficients provide an insight into scaling properties of actual seismicity and are of specific interest to seismologists working on seismic zonation and risk assessment.

The USLE Direct implications for assessing seismic hazard at a given location (e.g., in a mega city)

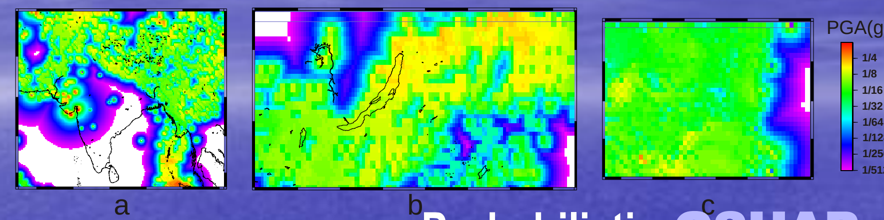
The estimates for Los Angeles (SCSN data, 1984-2001) -
A = -1.28; B = 0.95; C =1.21 (σ_{total} = 0.035)
- imply a traditional assessment of recurrence of a large earthquake in Los Angeles,
i.e., an area with L about 40 km,
from data on the entire southern California, i.e., an area with L about 400 km,
being **underestimated by a factor of** $10^2 / 10^{1.21} = 10^{0.79}$ **> 6 !**

Similarly, the underestimation is about a factor of
6.4 for San Francisco (A = -0.38, B = 0.93, C = 1.20, σ_{total}=0.07),
4.6 for Tokyo (A = 0.14, B = 0.94, C = 1.34, σ_{total}=0.05),
8 for Petropavlovsk-Kamchatsky (A = -0.01, B = 0.83, C = 1.22, σ_{total}=0.05),
10 for Irkutsk (A = -1.12, B = 0.80, C = 1.05, σ_{total}=0.03),
etc.

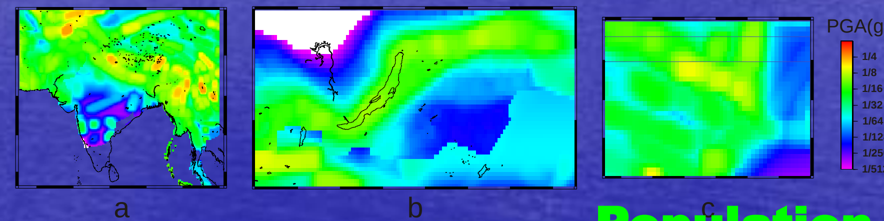
Nekrasova, A, Kossobokov, V, Parvez, IA, Tao, X (2015)
Seismic hazard and risk assessment based on the unified scaling law for earthquakes.
Acta Geod Geophys 50:21-37; https://doi.org/10.1007/s40328-014-0082-4

The USLE model outscore GSHAP in identifying correctly the sites of moderate, strong, and significant earthquakes. Specifically, **the number of unacceptable errors, when PGA on a map at epicenter of real earthquake is less, by factor 2 or greater, than attributed to this earthquake, is several times larger for the GSHAP map than for the USLE one (e.g., 11.4, 1.7, and 2.5 times for strong earthquakes in Himalayas and surroundings, Lake Baikal, and Central China region, respectively)**. This cannot be attributed to the difference of the empirical probability distributions of the model PGA values in a region, although evidently USLE model favors larger estimates in Baikal and Central China regions. Note that at the regional scale of investigation the GSHAP estimates of seismic hazard can be grossly underestimated in the areas of sparse explorations of seismically active faults, like those to the east of the upper segment of the Baikal rift zone.

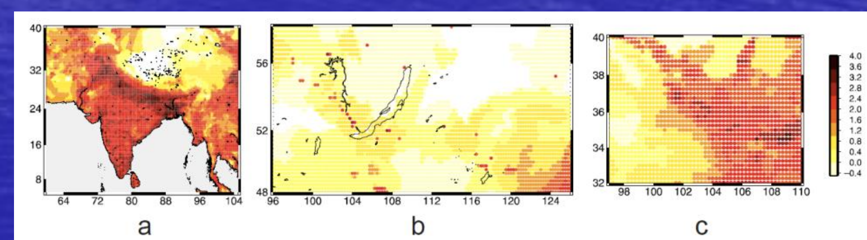
Neo-deterministic NDSHA based on USLE



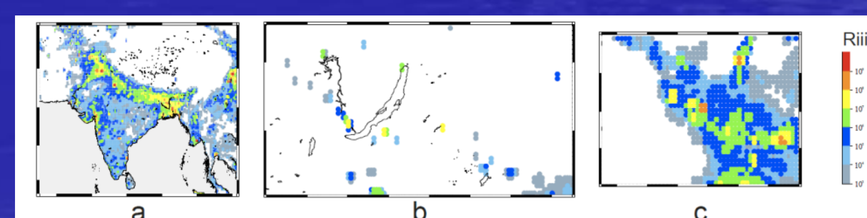
Probabilistic GSHAP



Population

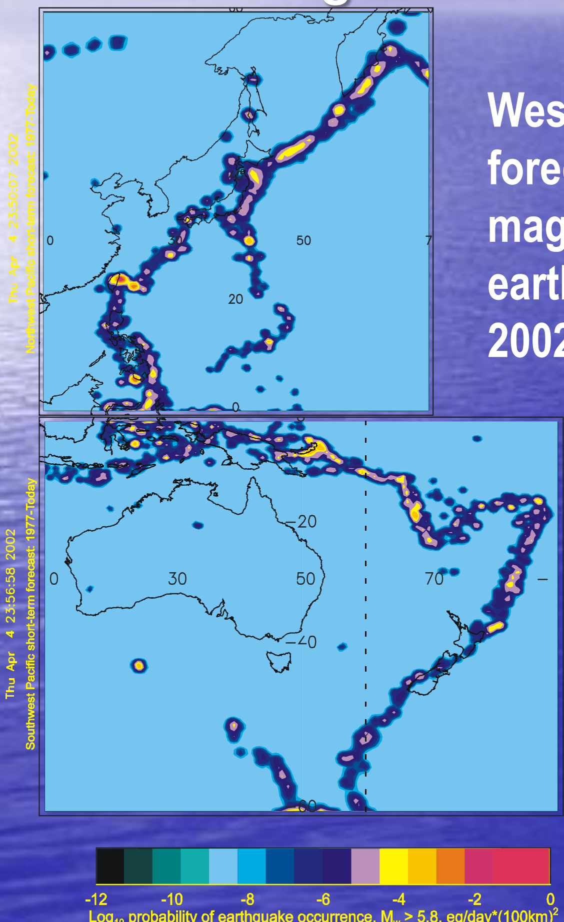


Risk

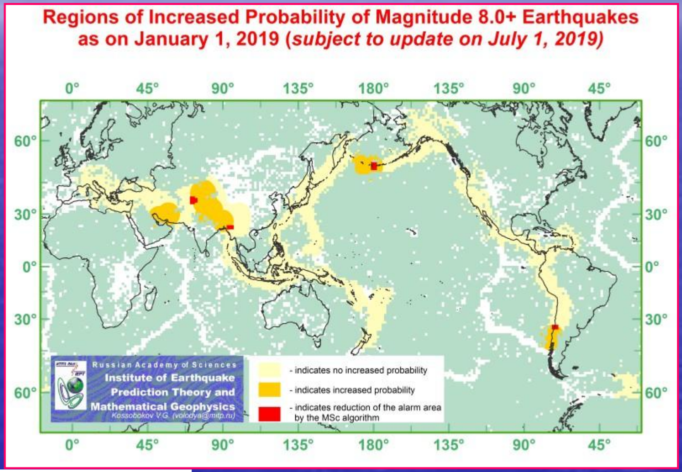


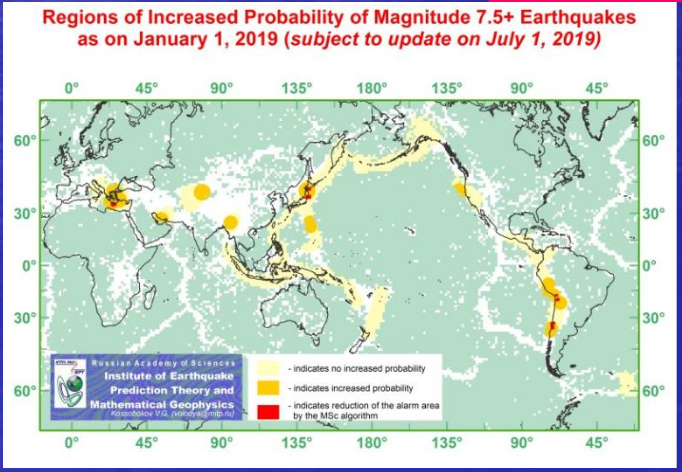
Applying simple tools of earthquake prediction strategies

Let us illustrate how Error Diagram and Seismic Roulette work for assessing efficiency of an earthquake forecast/prediction method with the following two examples.

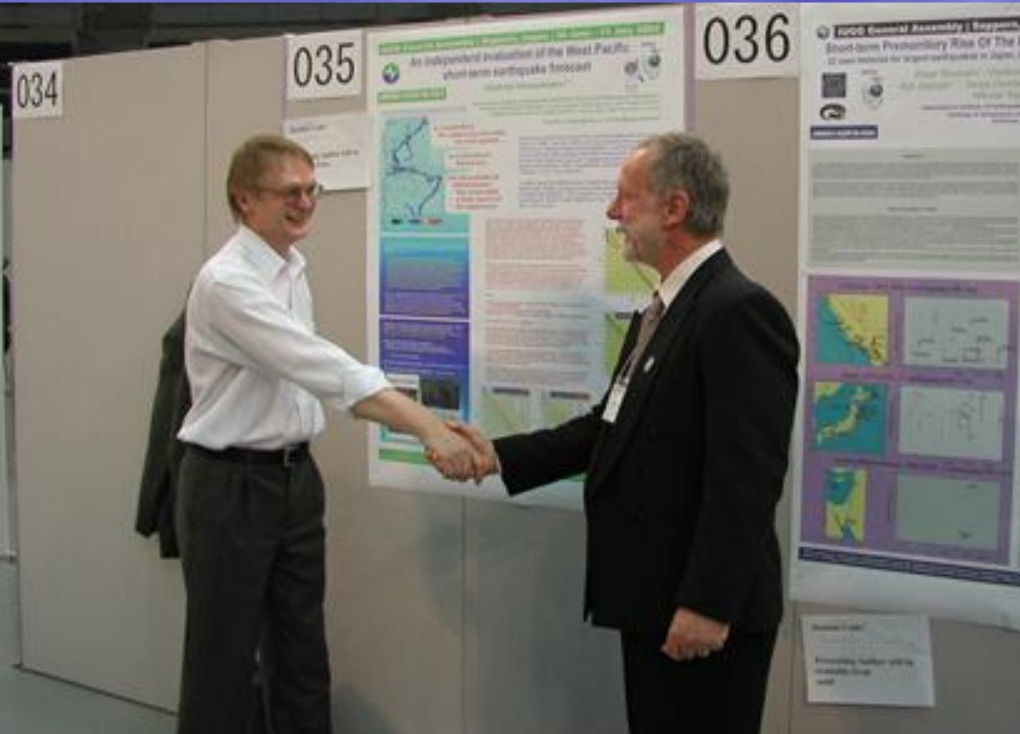


West Pacific short-term forecast of the shallow magnitude MwHRV ≥ 5.8 earthquakes in April 10, 2002 – September 13, 2004.



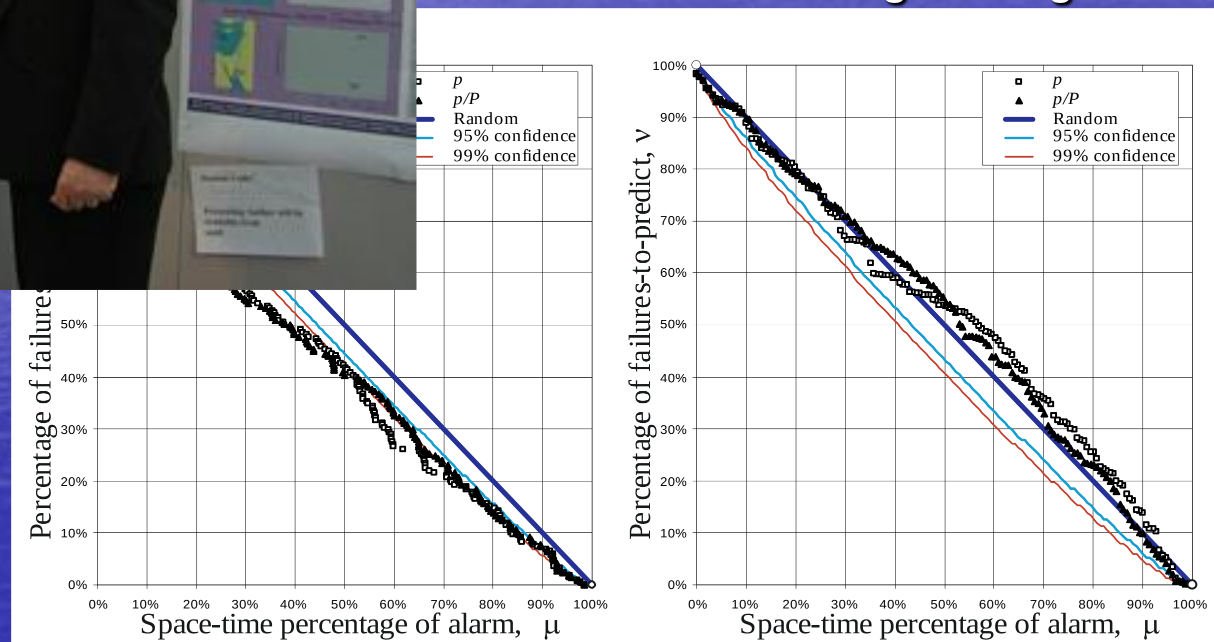


Global testing the earthquake prediction algorithms M8 and M8-MSc.



ecast of earthquakes

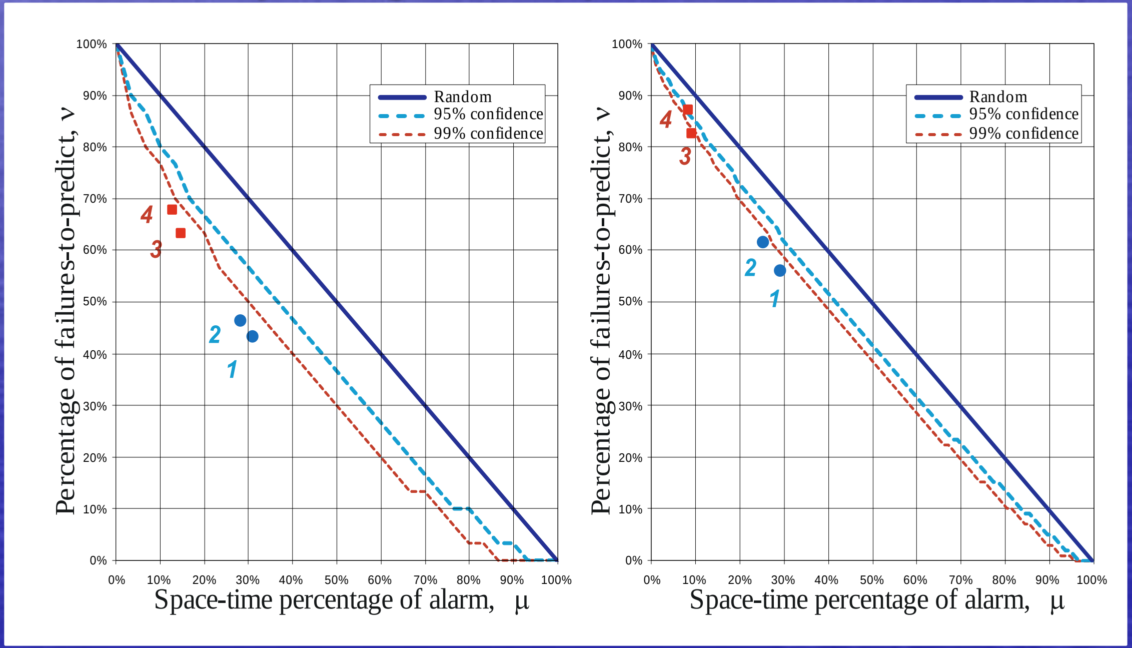
cast of earthquakes by Jackson and
ollowing 2.4-year period, the conclusion
rlying method is efficient for prediction
smic Roulette random guessing of the



Jackson and Kagan (1999) "Testable earthquake forecasts for 1999", Seism. Res. Lett., 70, 393-403
Kagan and Jackson (2000) "Probabilistic forecasting of earthquakes", Geophys. J. Int., 143, 438-453
Kossobokov, V.G. (2006) Testing earthquake prediction methods: «The West Pacific short-term forecast of earthquakes with magnitude MwHRV = 5.8». *Tectonophysics* **413:** 25–31

Global testing the earthquake prediction algorithms M8 and M8-MSc

This experiment started in July 1991 (Healy et al., 1992) being encouraged by the results of retrospective simulation of the algorithm M8 predictions of *M*7.5+ earthquakes in 1985–1991. Since then the semiannual up-to-date predictions are regularly sent to a group of internationally recognized experts.



Error Diagrams for the M8 and M8-MSc algorithms' strategies targeting earthquakes in magnitude ranges M8.0+ (on the left) and M7.5+ (on the right): M8 in 1985–2021 (1) and 1992–2021 (2); M8–MSc in 1985–2013 (3) and 1992–2021 (4). The lower 95 and 99% confidence limits obtained by random guessing in 30 and 98 independent identically distributed trials given in cyan and red, respectively.

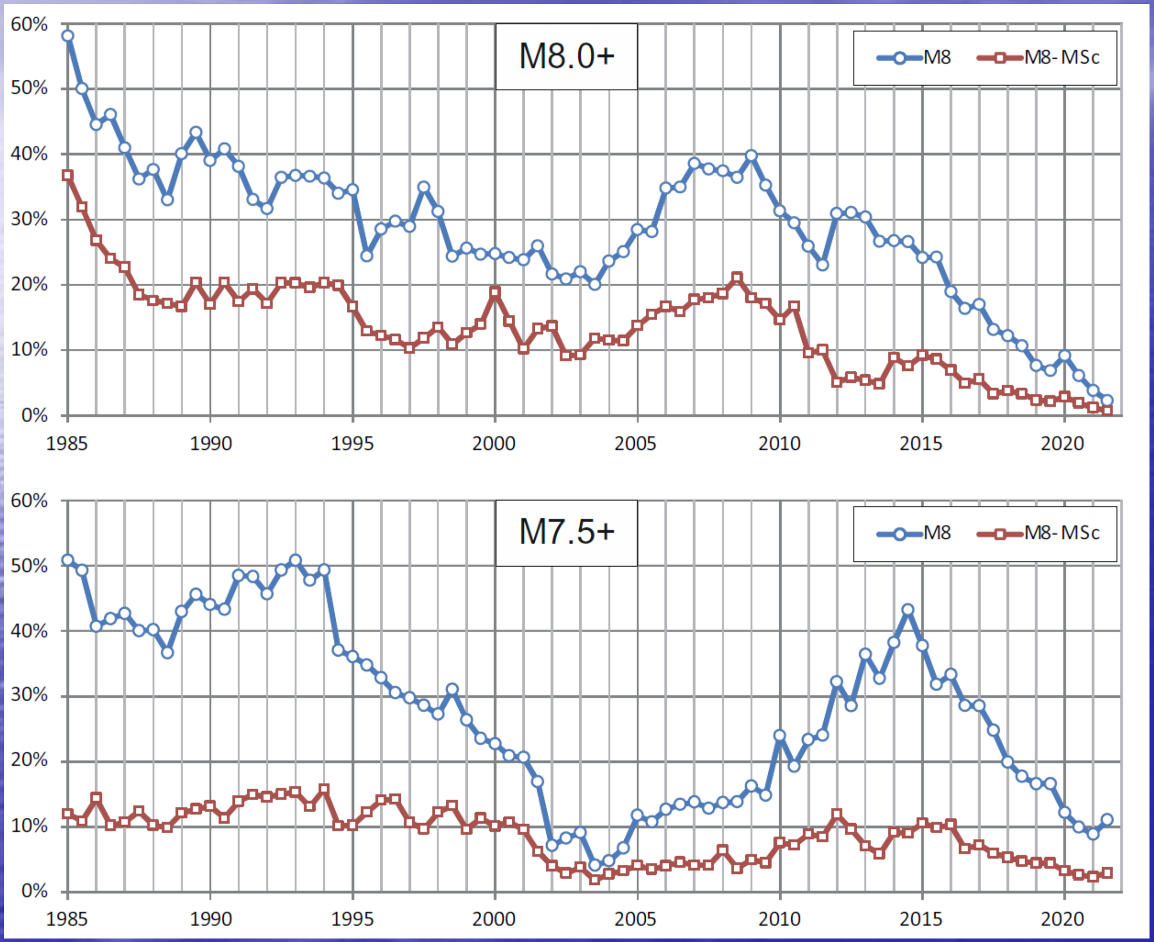
The performance of the M8 and M8-MSc predictions

Period	Target Earthquakes			Space-Time Volume, μ		Confidence	
	Total	M8	M8-MSc	M8	M8-MSc	M8	M8-MSc
Magnitude range M8.0+							
1985-present	30	17	11	28.63%	13.41%	99.88%	99.88%
1992-present	28	15	9	25.62%	11.42%	99.85%	99.70%
Magnitude range M7.5+							
1985-present	98	43	17	27.71%	8.59%	99.96%	99.60%
1992-present	86	33	11	23.93%	7.78%	99.80%	93.03%

Notes: "Target Earthquakes" are earthquakes of the magnitude range M8.0+ or M7.5+ which "Total" refers to their total number in the union of all CIs during the study "Period", and "M8" and "M8-MSc" refer to the number of those earthquakes that occurred in the space-time volumes covered by the M8 and M8-MSc alerts, respectively. "Space-Time Volume" of the M8 and M8-MSc predictions is given in percent to the total space-time volume, ì, of seismic loci in all CIs during the study Period. The "Confidence" level tells how sure one can be that the achieved performance is not arisen by chance in the binomial trials.

Kossobokov, V.G., Soloviev, A.A. (2021) Testing Earthquake Prediction Algorithms. Journal Geological Society of India, 97, pp.1514-1519. https://doi.org/10.1007/s12594-021-1907-8

Changes over time in the μ-volume of M8 and M8-MSc alarms targeting earthquakes in the M8.0+ and M7.5+ ranges.



Note that for the semiannual evaluation of μ, we used a measure that is proportional to the number of epicenters of earthquakes with M ≥ 4.0 in 1964–1984, which does not depend on earthquakes in testing time period. We observe a steady gradual decrease of μ targeting either M8.0+ or M7.5+ in advance the 2004 Sumatra-Andaman MW 9.0 mega-earthquake, and another decrease in the recent 5-10 years to the minimal values that may explain a few failures-to-predict since 2018..

Reliable Seismic Hazard Assessment , RSHA

NDSHA представляет собой инновационный междисциплинарный подход,
основанный на физике сценариев землетрясений и ориентированный на
практическо … трясение
поверхност…
соответстви … м
Сейсмическ … А), оценки
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Terra Nova WILEY

REVIEW ARTICLE

Seismic roulette: Hazards and risks

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Russian Science Foundation

Abstract

The Neo Deterministic Seismic Hazard Assessment (NDSHA) is the innovative multidisciplinary scenario-physics-based approach for the evaluation of seismic hazard and risks. When an earthquake occurs, the ground shaking does not depend on its likelihood according to the widespread Probabilistic Seismic Hazard Analysis (PSHA), which estimates are too often wrong. An "unlikely" earthquake can occur at any time and, sooner or later, with 100% probability. Therefore, from a perspective of safety, it is essential that infrastructure and public installations are designed so as to resist future strong earthquakes. NDSHA has proven to both reliably and realistically simulate comprehensive sets of hazardous ground motions in many regions worldwide. Today NDSHA is gaining momentum in spreading worldwide an innovative Paradigm of Reliable Seismic Hazard Assessment (RSHA) that should ultimately change mind-sets of scientific and engineering communities from disbelief in probabilistic forecasting to optimistic challenging issues of neo-deterministic predictability of Natural Hazards and Risks.

The confirmed reliability of pattern recognition results, along with realistic and exhaustive neo-deterministic scenario based modeling and testing against Reality, allow concluding that –

Nowadays, Science can disclose Natural Hazards, assess Risks, and deliver the state-of-the-art Knowledge of looming Disaster (in advance catastrophes) along with useful Recommendations on the level of risks for decision making in regard to engineering design, insurance, and emergency management.

A knot that ties together Hazard, Location, Time, Exposure, and Vulnerability all around Risk.

"If you are right and you know it, speak your mind. Speak your mind even if you are a minority of one. The truth is still the truth."

(Mohandas Karamchand Gandhi, 1869 – 1948)

Neo-Deterministic Seismic Hazard Assessment (NDSHA) dates back to the turn of Millennium providing an alternative to PSHA approach. It represents the innovative scenario- and physics-based multidisciplinary approach for the evaluation of seismic hazard, proven reliable by twenty years of experiments in many countries worldwide.

Fäh, D.; Iodice, C.; Suhadolc, P.; Panza, G.F. (1993) A new method for the realistic estimation of seismic ground motion in megacities: the case of Rome. Earthquake Spectra 1993, 9(4), 643-668. https://doi.org/10.1193/1.1585735

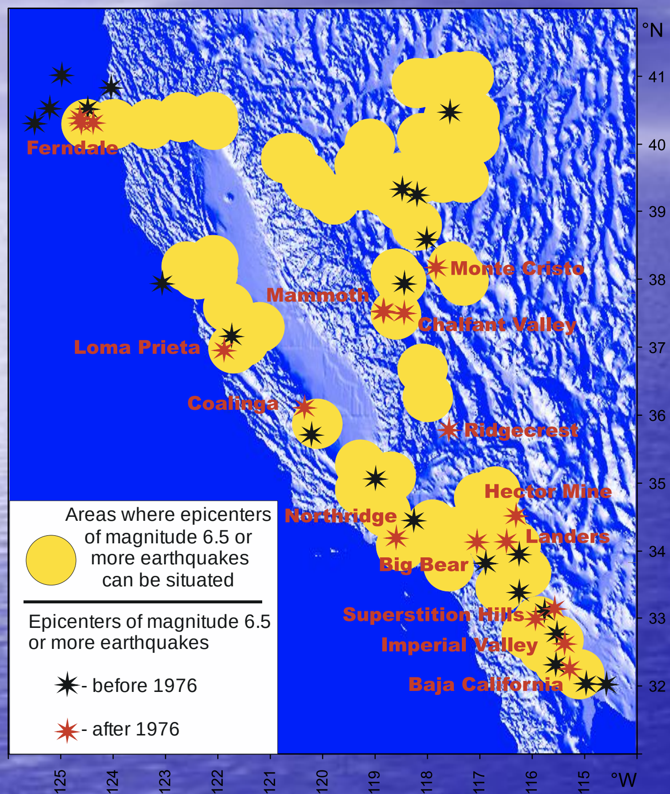
Panza, G.F.; Romanelli, F.; Vaccari, F. (2001) Seismic wave propagation in laterally heterogeneous anelastic media: Theory and applications to seismic zonation. Advances in Geophysics 43, 1-95. https://doi.org/10.1016/S0065-2687(01)80002-9

Evidently, the results of NDSHA applications outscore the widespread PSHA results by taking advantage of a synergy between to-date available Pattern Recognition of Earthquake Prone Areas (PREPA), Intermediate-Term Earthquake Prediction (ITEP) of different spatial accuracy, Scenario-based Seismic Hazard Analysis (SSHA), Maximum Credible Seismic Input (MCSI) method, Unified Scaling Law for Earthquakes (USLE) that accounts for fractal distribution of seismic occurrence, and Geodetic Data Analysis (GDA) of GPS, GSSN and other reliable determinations.

The synergy of **PREPA×USLE×ITEP×GDA×MCSI×SSHA**

Pattern Recognition of Earthquake Prone Areas (PREPA)

Kossobokov V.G., Soloviev A.A. (2018) Pattern recognition in problems of seismic hazard assessment. Chebyshevskii Sbornik 19(4): 55-90. (In Russian) https://doi.org/10.22405/2226-8383-2018-19-4-55-90
Gorshkov, A.; Novikova, O. (2018) Estimating the validity of the recognition results of earthquake-prone areas using the ArcMap. Acta Geophysica 2018, 66(5), 843–853. https://doi.org/10.1007/s11600-018-0177-3



The 40-km radius outlines of the D-intersections of morphostructural lineaments in California and Nevada and epicenters of magnitude 6.5+ earthquakes before (black stars) and after (red stars) publication of (Gelfand et al., 1976).

The PREPA termless prediction for California and Nevada is statistically justified by the subsequent occurrence of the 16 out of 17 magnitude M6.5+ earthquakes in a narrow vicinity of the 73 D-intersections of morphostructural lineaments (yellow circles) determined as prone to seismic events that large. The target earthquakes include the recent most May 15, 2020, M6.5 Monte Cristo Range (NV) earthquake and July 6, 2019, M7.1 Ridgecrest (CA) main shock, i.e. the exceptional near-miss within the study area since 1976. It is also notable that the Puente Hills thrust fault beneath metropolitan Los Angeles coincides exactly (Kossobokov, 2013) with the lineament drawn back in 1976, decades in advance it was “rediscovered” by the 1995 Northridge earthquake (Shaw, Shearer, 1999).

Gelfand, I.M.; Guberman, Sh.A.; Keilis-Borok, V.I.; Knopoff, L.; Press, F.; Ranzman, E.Ya.; Rotwain, I.M.; Sadovsky, A.M. (1976) Pattern recognition applied to earthquake epicenters in California. PEPI 11(3), 227-283. https://doi.org/10.1016/0031-9201(76)90067-4
Kossobokov, V.G. (2013) Earthquake prediction: 20 years of global experiment. Natural Hazards 69(2):1155–1177; https://doi.org/10.1007/s11069-012-0198-1
Shaw, J.H.; Shearer, P.M. (1999) An elusive blind-thrust fault beneath metropolitan Los Angeles. Science 283(5407), 1516-1518. https://doi.org/10.1126/science.283.5407.1516

The synergy of **PREPA×USLE×ITEP×GDA×MCSI×SSHA**

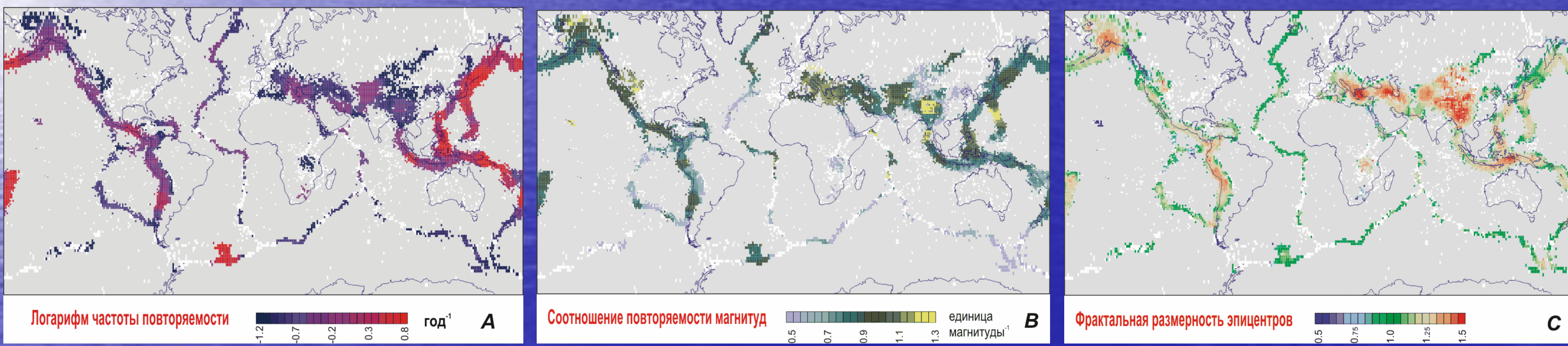
Unified Scaling Law for Earthquakes (USLE)

The Unified Scaling Law for Earthquakes generalizes the classical Gutenberg-Richter relationship accounting for the local fractal structure of the lithosphere as follows -

$$\log_{10}N = A + B\cdot(5 - M) + C\cdot\log_{10}L$$

where N = N(M, L) is the expected annual number of earthquakes with magnitude M in an earthquake-prone area of linear dimension L.

Nekrasova, A., and V. Kossobokov, Generalizing the Gutenberg-Richter scaling law. *EOS Trans. AGU*, **83** (47), Fall Meet. Suppl., Abstract NG62B-0958, 2002

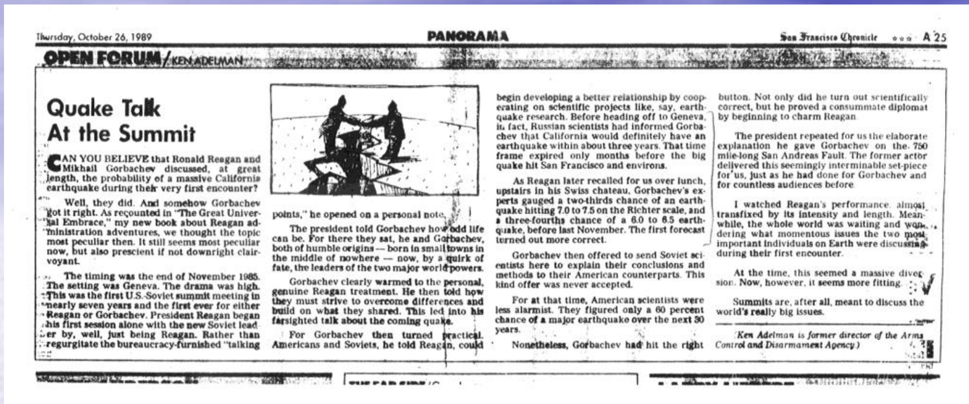


Nekrasova AK, Kossobokov VG. USLE: Global map of parameters, *ISC's Seismological Dataset Repository*, 2019. https://doi.org/10.31905/XT753V44

One of the very first practical conclusions drawn from USLE: Kosobokov and Mazhkenov (1988, 1994) demonstrated that in case of the Lake Baikal region with the area of 1,500,000 km^2 and C = 1.25, the inclusion of aseismic areas leads to **underestimation** of widespread seismic activity measure A_{10} in 1000 km^2 **by a factor of 15**, and to its **overestimation by a factor greater than 2** when a characteristic of seismic activity over an area of 1000 km^2 is computed for a grid cell of 10 km × 10 km.

The synergy of **PREPA×USLE×ITEP×GDA×MCSI×SSHA**

Intermediate-Term Earthquake Prediction (ITEP)



Thursday, October 26, 1989 PANORAMA San Francisco Chronicle A 25

OPEN FORUM/KEN ADELMAN

Quake Talk At the Summit

CAN YOU BELIEVE that Ronald Reagan and Mikhail Gorbachev discussed, at great length, the probability of a massive California earthquake during their very first encounter?

Well, they did. And somehow Gorbachev got it right. As recounted in "The Great Universal Embrace," my new book about Reagan administration adventures, we thought the topic most peculiar then. It still seems most peculiar now, but also prescient if not downright clairvoyant.

The timing was the end of November 1985. The setting was Geneva. The drama was high. This was the first U.S.-Soviet summit meeting in nearly seven years and the first ever for either Reagan or Gorbachev. President Reagan began his first session alone with the new Soviet leader by, well, just being Reagan. Rather than regurgitate the bureaucracy-furnished "talking points," he opened on a personal note.

The president told Gorbachev how odd life can be. For there they sat, he and Gorbachev, both of humble origins — born in small towns in the middle of nowhere — now, by a quirk of fate, the leaders of the two major world powers.

Gorbachev clearly warmed to the personal, genuine Reagan treatment. He then told how they must strive to overcome differences and build on what they shared. This led into his farsighted talk about the coming quake.

For Gorbachev then turned practical. Americans and Soviets, he told Reagan, could begin developing a better relationship by cooperating on scientific projects like, say, earthquake research. Before heading off to Geneva, in fact, Russian scientists had informed Gorbachev that California would definitely have an earthquake within about three years. That time frame expired only months before the big quake hit San Francisco and environs.

As Reagan later recalled for us over lunch, upstairs in his Swiss chateau, Gorbachev's experts gauged a two-thirds chance of an earthquake hitting 7.0 to 7.5 on the Richter scale, and a three-fourths chance of a 6.0 to 6.5 earthquake, before last November. The first forecast turned out more correct.

Gorbachev then offered to send Soviet scientists here to explain their conclusions and methods to their American counterparts. This kind offer was never accepted.

For at that time, American scientists were less alarmist. They figured only a 60 percent chance of a major earthquake over the next 30 years.

Nonetheless, Gorbachev had hit the right button. Not only did he turn out scientifically correct, but he proved a consummate diplomat by beginning to charm Reagan.

The president repeated for us the elaborate explanation he gave Gorbachev on the 750 mile-long San Andreas Fault. The former actor delivered this seemingly interminable set-piece for us, just as he had done for Gorbachev and for countless audiences before.

I watched Reagan's performance, almost transfixed by its intensity and length. Meanwhile, the whole world was waiting and wondering what momentous issues the two most important individuals on Earth were discussing during their first encounter.

At the time, this seemed a massive diversion. Now, however, it seems more fitting.

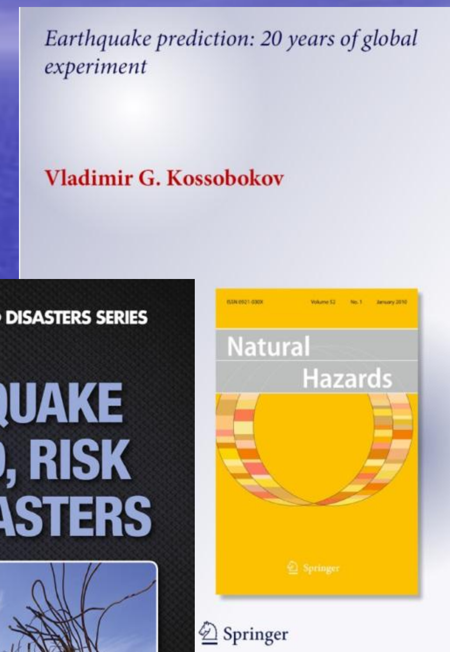
Summits are, after all, meant to discuss the world's really big issues.

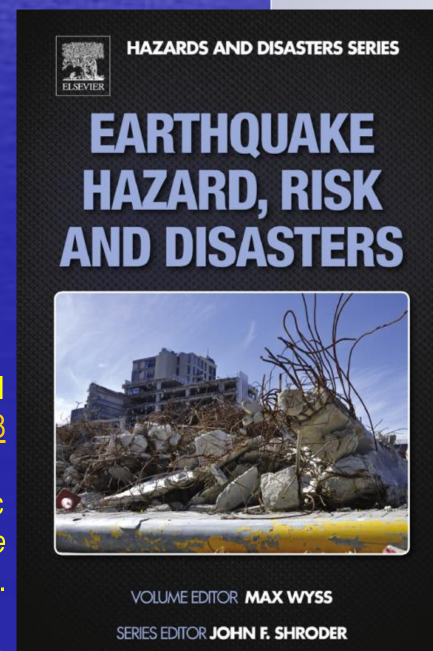
(Ken Adelman is former director of the Arms Control and Disarmament Agency.)

Healy, J. H., V. G. Kossobokov, and J. W. Dewey (1992) *A test to evaluate the earthquake prediction algorithm, M8,* U.S. Geol. Surv. Open-File Report 92-401, 23 p. with 6 Appendices

M8-MSc

algorithms





The results of truly global 30-year experiment are indirect confirmations of the existing common features of both the predictability and the diverse behavior of the Earth's naturally fractal lithosphere.

The statistics achieved to date prove (with confidence above 99%) rather high efficiency of the M8 and M8-MSc predictions limited to intermediate-term middle- and narrow-range accuracy.

Kossobokov, V.G., Soloviev, A.A. (2021) Testing Earthquake Prediction Algorithms. Journal Geological Society of India, 97, pp.1514-1519. https://doi.org/10.1007/s12594-021-1907-8

Kossobokov V (2014) Chapter 18. Times of Increased probabilities for occurrence of catastrophic earthquakes: 25 years of hypothesis testing in real time. In: Wyss M, Shroder J (eds) *Earthquake Hazard, Risk, and Disasters*. Elsevier, London, 477-504.

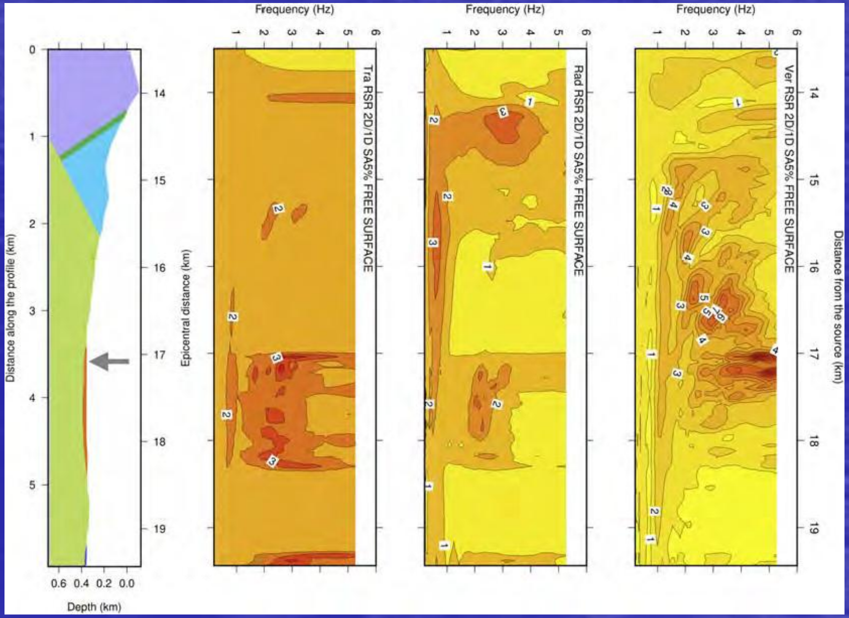
Kossobokov VG (2013) Earthquake prediction: 20 years of global experiment. *Natural Hazards* **69**(2):1155–1177; https://doi.org/10.1007/s11069-012-0198-1

The synergy of **PREPA×USLE×ITEP×GDA×MCSI×SSHA**

Scenario-based Seismic Hazard Analysis (SSHA)

SSHA рассматривает исчерпывающий набор сценариев возможных землетрясений из доступных сейсмических источников и структурных моделей, вычисляет движения грунта при землетрясении как тензорное произведение тензора очага землетрясения на функцию Грина для среды (что позволяет избежать использования подразумеваемой скалярной величины (так называемой Ground Motion Prediction Equation - GMPE) и обеспечивает физически обоснованную огибающую пиковых значений сотрясаемости объекта риска.

Графики усиления трех компонентов движения (вертикального - Ver, радиального - Rad и поперечного - Tra) для сценария M = 6.0 Branik по выбранному профилю, пересекающему г. Триест; серая стрелка показывает положение выбранного сайта для дальнейшего анализа объекта риска.



The synergy of **PREPA×USLE×ITEP×GDA×MCSI×SSHA**

Scenario-based Seismic Hazard Analysis (SSHA)

SSHA рассма ... жных
землетрясени ... турных
моделей, выч ... ензорное
произведение ... для среды (что
позволяет изб ... ой величины
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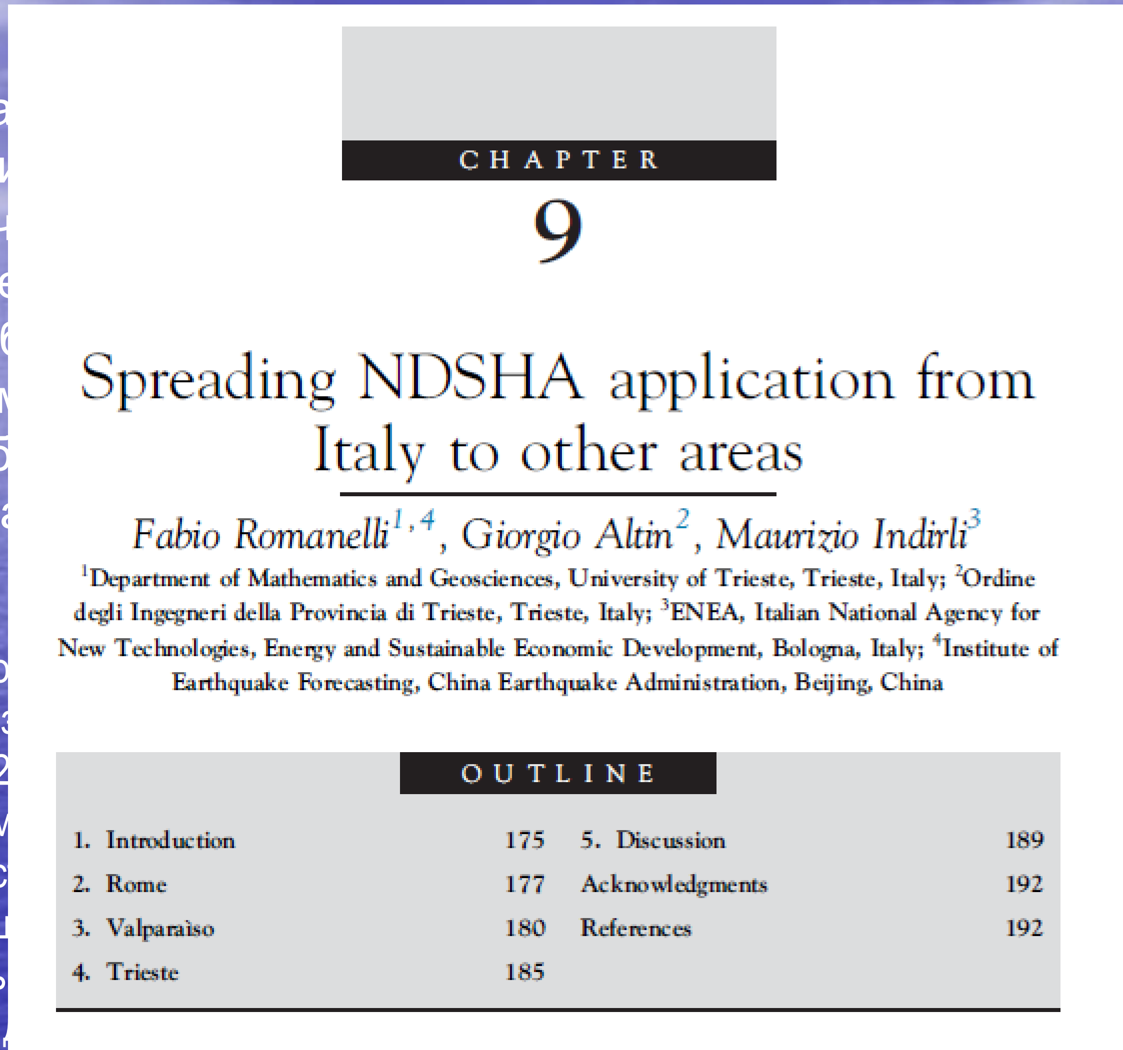
физически об ... аемости
объекта риск...



CHAPTER

9

Spreading NDSHA application from Italy to other areas

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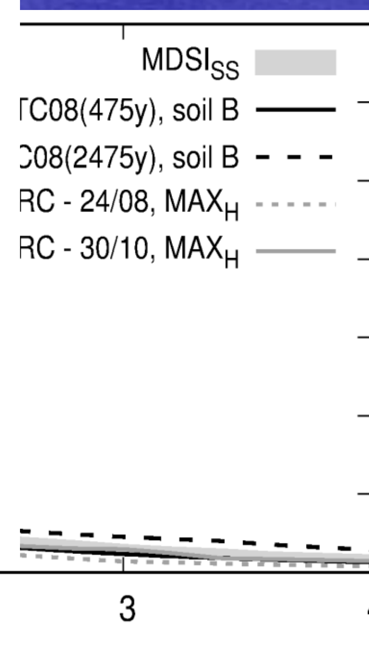
OUTLINE



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когда-либо зарегис...
этом районе, хорош...
MCSI, рассчитанны...
подходом NDSHA ...
разрушительного землетрясения.

The synergy of **PREPA×USLE×ITEP×GDA×MCSI×SSHA**

Maximum Credible Seismic Input (MCSI)

Консервативные оценки ожидаемой максимальной достоверной сейсмической магнитудыполучаются на основе фактического эмпирического распределения характеристик землетрясений, дополненного (1) существующими геологическими, тектоническими, макро- и палеосейсмическими данными, (2) результатами PREPA и (3) оценками на основе USLE, который учитывает локально фрактальную структуру литосферы.

Natural Hazards

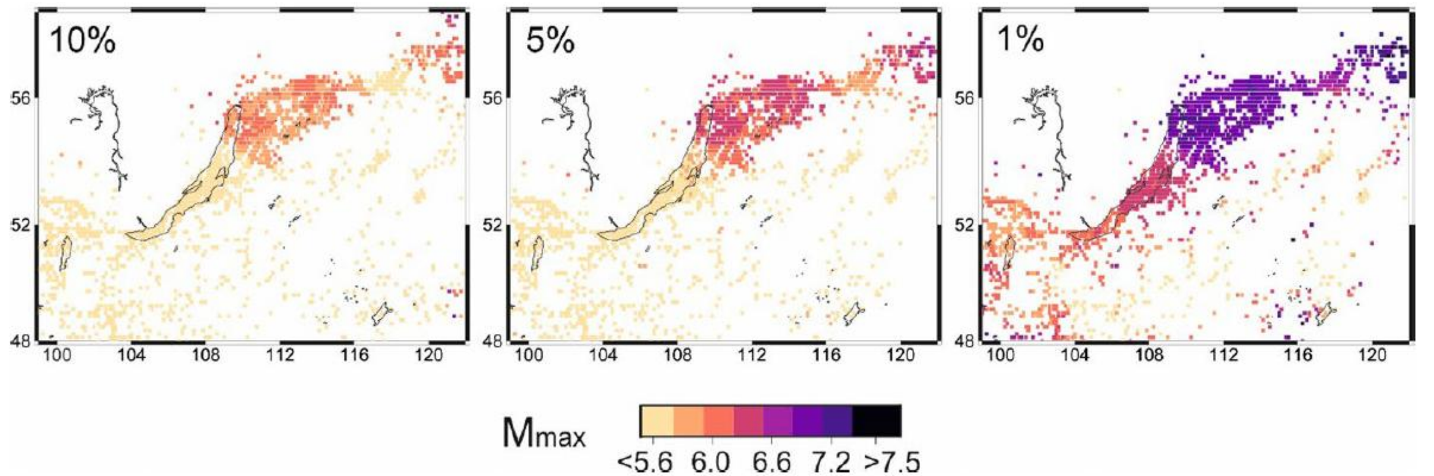
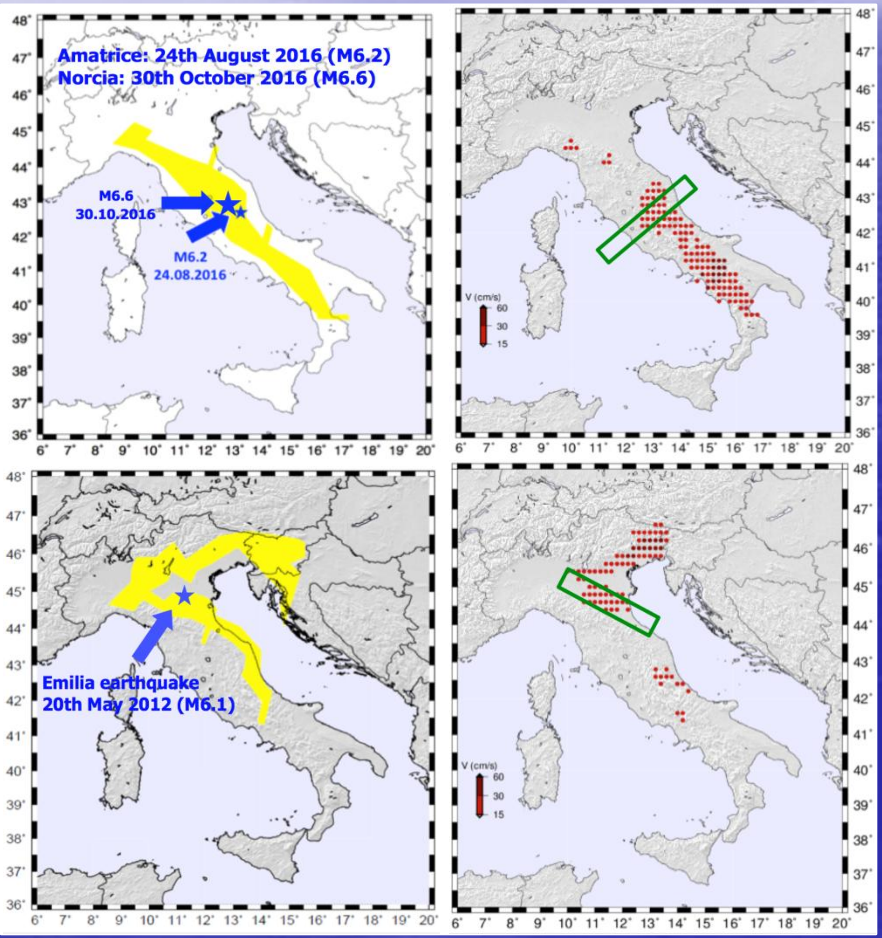


Fig. 4 The seismic hazard maps for the Lake Baikal Region in terms of *M*max expected at earthquake-prone cells of the regular 1/8°×1/8° grid in 50 years with 10%, 5% and 1% chance of exceedance

The synergy of **PREPA×USLE×ITEP×GDA×MCSI×SSHA**

Geodetic Data Analysis (GDA)

Crespi M, Kossobokov V, Peresan A, Panza GF (2022) The Integration between Seismology and Geodesy for Intermediate-Term Narrow-Range Earthquake Prediction according to NDSHA. In: Panza G, Kossobokov V, De Vivo B, Laor E (Eds) (2022) Earthquakes and Sustainable Infrastructure: neo-deterministic (NDSHA) approach guarantees prevention rather than cure, Elsevier. ISBN: 9780128235034, 97-112. https://doi.org/10.1016/B978-0-12-823503-4.00003-8

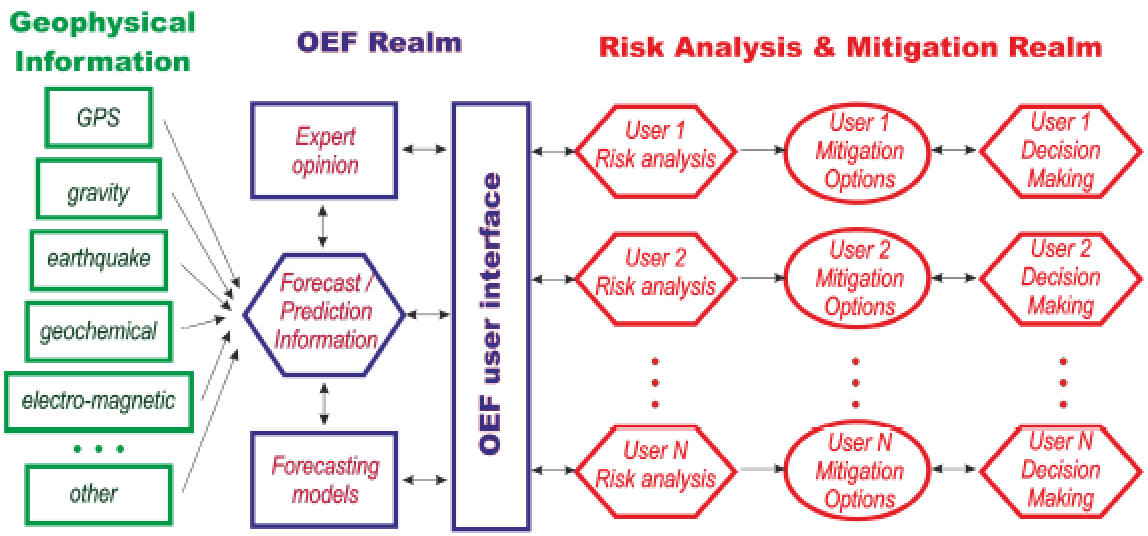


Справа зоны тревоги по CN (желтый полигон) и эпицентры (синие звезды) землетрясений 2016 Аматриче, 2016 Норсия и 2012 Эмилия. Слева пересечение разреза с возможным геодезическим признаком (зеленый прямоугольник) и сценарием сотрясения земли по NDSHA в пределах области (цветные узлы регулярной сетки), что ведет к уменьшенной области, где должны быть сосредоточены превентивные действия по снижению сейсмического риска.

Operational earthquake forecasting, oef

В рамках оперативного прогнозирования землетрясений (OEF), которое представляет собой «распространение достоверной информации о зависящих от времени вероятностях землетрясений, чтобы помочь сообществам подготовиться к потенциально разрушительным землетрясениям» (Jordan et al., 2014), в рамках более широкой схемы OEF (рис. 5) следует стараться использовать всю надежную геофизическую информацию, которая может иметь отношение к возникновению разрушительных сотрясений грунта.

FIGURE 5 Operational earthquake forecasting scheme.



Operational earthquake forecasting, oef

Seismology and computer science are not enough for a successful collaboration aimed at effective forecasting of larger earthquakes. OEF could be either deterministic, probabilistic, or a combination of both in interaction with user needs within the Realm of Risk Analysis and Mitigation. Naturally, the scheme applies as well to other natural hazards and can be further generalized. Note however, that 'operational' (in everyday language) means 'ready to work correctly'; hence, it is obvious that SHA belongs to the OEF Realm as the most important part of the OEF user interface.

Сейсмологии и информатики недостаточно для успешного взаимодействия, направленного на эффективное прогнозирование наиболее сильных землетрясений. OEF может быть детерминистическим или вероятностным, или их комбинацией во взаимодействии с потребностями пользователей Королевства Анализа и Снижения Рисков. Естественно, эта схема применима и к другим опасным природным явлениям и может быть дополнительно обобщена. Обратите внимание, однако, что «оперативный» (на повседневном языке) означает «готовый к правильной работе {способный быстро, вовремя исправить или направить ход дела}**»; следовательно, очевидно, что оценка сейсмической опасности (*SHA) принадлежит Королевству OEF как наиболее важной части пользовательского интерфейса OEF.**

Reliable Seismic Hazard Assessment , RSHA

Сегодня NDSHA набирает обороты в распространении по всему миру инновационной Парадигмы Надежной Оценки Сейсмической Опасности (Reliable Seismic Hazard Assessment, RSHA; см. Bela & Panza, 2021; Panza & Bela, 2020**), включающей методологии моделирования детерминированных сценариев землетрясений на основе физики (**платформы XeRiS - Vaccari & Magrin, 2019; https://www.xeris.it/Methodology/index.html и CyberShake - SCEC, 2018**), которая в конечном итоге должна изменить образ мышления научного и инженерного сообщества от неверия в вероятностное прогнозирование к оптимистичным сложным вопросам нео-детерминистской предсказуемости природных опасностей и рисков.**

Discussion and Conclusions

Charles Richter, whose critical observation that "only fools and charlatans predict earthquakes" is often cited, wrote a one third of a page note (Richter, 1964) next to (Keylis-Borok and Malinovskaya, 1964) that described quantitatively an observation of general increase in seismic activity in advance 20 strong earthquakes. He noted "a creditable effort to convert this rather indefinite and elusive phenomenon into a precisely definable one", marked as important a confirmation of "the necessity of considering a very extensive region including the center of the approaching event", and outlined "difficulty and some arbitrariness, as the authors duly point out, in selecting the area which is to be included in each individual study".

One could not argue that operational earthquake forecast/prediction research requires from a scientist a keen feeling of responsibility and rigid control of all claims and conclusions (Kossobokov et al., 2015). This responsibility requires as well the high standard of statistical analysis. It is well-known that improper use of statistical tools may lead to wrong, although user desirable, inferences. This was often reminded to us by Andrei N. Kolmogorov (1903-1987), the famous Russian mathematician known for Probability theory, Topology, Intuitionistic logic, Turbulence and many other studies, who modified for this purpose a famous quotation attributed to Benjamin Disraeli (1804-1881): **"There are three kinds of lies: lies, damned lies, and *political* statistics."**

It would be also wrong to regard statistics as a tool for exercises in numerology by counting "descriptive" parameters. The problem of widespread scientific crisis lies in misuse of statistics beyond the possibilities of its application in many disciplines due to superficial education, lots of mechanical application of available software, and editorial policy of scientific journals (Stark, 2018; Stark and Saltelli, 2018).

Nevertheless, Seismic Roulette is not perfect!

Therefore, seismic hazard assessment and earthquake prediction claims can be useful for reducing future impacts from disastrous earthquakes, if reliable, but not necessarily perfect.

Seismic Roulette is a game of chance. Disastrous earthquakes are low-probability events locally; however, in any of the earthquake-prone areas worldwide, they reoccur with certainty, i.e., with 100% probability sooner or later.

Nature spins the "wheel" and throws the earthquake "balls"...
and we can win the game, if we take a chance to play systematically.

Thank you!

“When sorrows come, they come not single spies, but in battalions”
(William Shakespeare, 1564-1616)