Coping with natural risk in the XXI century: new challenges for scientists and decision makers

Warner Marzocchi,
Istituto Nazionale di Geofisica e Vulcanologia

Outline

- The definition of hazard and risk
- Role and responsibilities of scientists and decision makers
- The example of Seismic hazard: state of the art and perspectives

The definition of hazard & risk

Risk = **Hazard** x **Exposed Value** x **Vulnerability**

Hazard is the **probability** of occurrence of a specific threat in a **space-time window**

Exposed Value: it is the **value** (economic, human lives, historical heritage, etc.) that is under threat

Vulnerability: it is often defined as a probability of an object/ person to be damaged by the event.

RISK **is not** HAZARD

(both are expressed in terms of probabilities)

Why probabilities?

- Natural systems usually yield an intrinsic unpredictability (due to nonlinear systems, high number of degrees of freedom, limited knowledge)

- Probabilities can be used to set up a rationale decision making system

The definition of hazard & risk

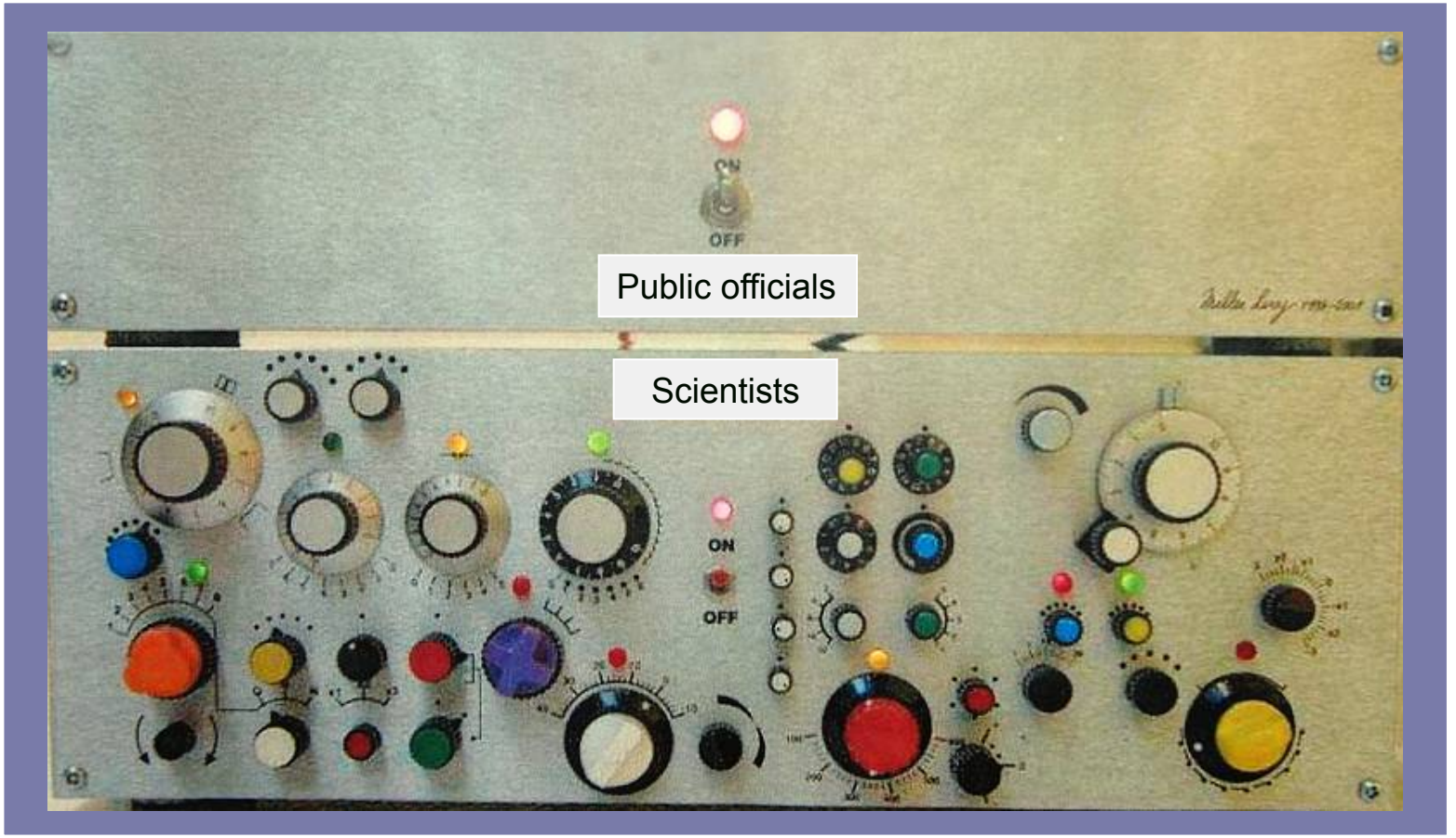
We live in a world of ***uncertainties*** (reducible and NOT reducible) and decisions have to be taken under these circumstances.

❖ ***Uncertainty*** in Science derives from the complexity, nonlinearity and limited knowledge. ***Probability*** is the best way (so far) to quantify ***uncertainties***.

❖ ***Uncertainty*** in decision-making means that, by definition, you cannot be always 'right'. In other words, ***it is impossible to choose always the decision that results to be the best also a posteriori.***

❖ ***Uncertainty*** in decision-making is ***pervasive***.
In our private life we always take decisions under uncertainties. We don't need to establish 'quantitative rules', because if something go wrong we can complain only against ourselves.
The problem is different if we have to decide for a society.

Role of scientists and decision makers



The link between science and decision making requires to map a continuous number (the probability) into a Boolean logic (go – not go) of the decision makers

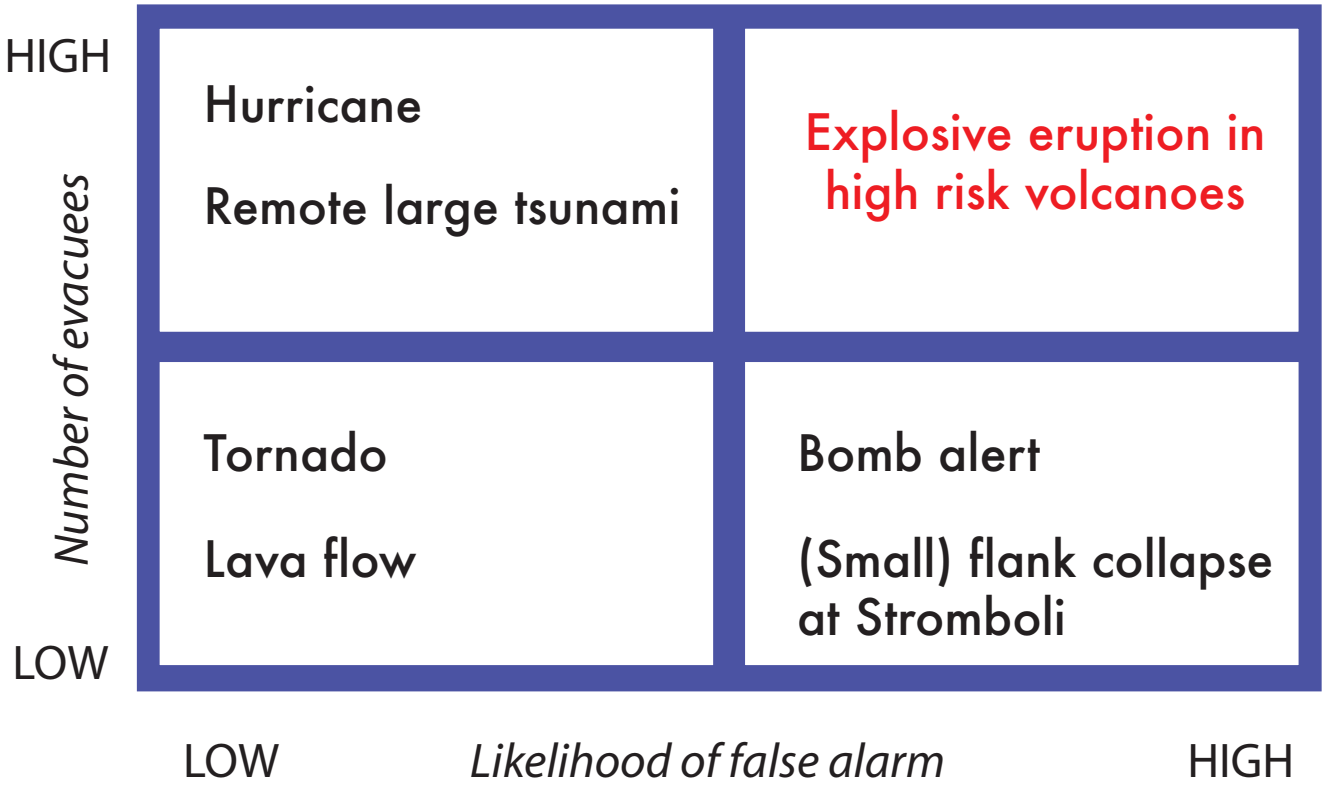
Role of scientists and decision makers

Traditional deterministic precautionary approach for Civil Protection

No risk assessment is needed for most evacuation decisions

Role of scientists and decision makers

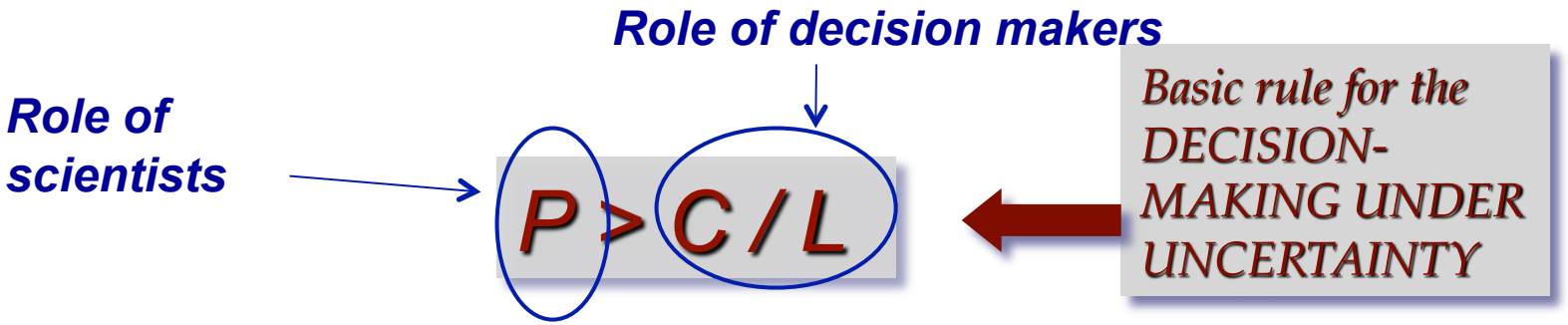
Quantitative Risk assessment is particularly important in some situations



Cost-benefit analysis

C is the cost of a mitigation action
P * L is the probable loss if the mitigation action is not taken

If P * L > C, the probable loss overcomes the costs of the mitigation action. So, a mitigation action becomes worthwhile when



C/L is a probability threshold, whose value does not have any scientific motivation (it is related to the acceptable risk)

Role of scientists and decision makers

Recommendations on the Immediate Use of Nuclear Weapons, June 16, 1945

Recommendations on the Immediate Use of Nuclear Weapons, by the Scientific Panel of the Interim Committee on Nuclear Power, June 16, 1945.

Source: U. S. National Archives, Record Group 77, Records of the Office of the Chief of Engineers, Manhattan Engineer District, Harrison-Bundy File, Folder #76.

TOP SECRET

THIS PAGE REGRADED UNCLASSIFIED
Order Sec Army By TAG per
720564

THIS DOCUMENT CONSISTS OF 2 PAGE(S)
NO. 1 OF 12 COPIES, SERIES A

RECOMMENDATIONS ON THE IMMEDIATE USE OF NUCLEAR WEAPONS

A. H. Compton
E. O. Lawrence
J. R. Oppenheimer
E. Fermi

[signature]
J. R. Oppenheimer
For the Panel

(3) With regard to these general aspects of the use of atomic energy, it is clear that we, as scientific men, have no proprietary rights. It is true that we are among the few citizens who have had occasion to give thoughtful consideration to these problems during the past few years. We have, however, no claim to special competence in solving the political, social, and military problems which are presented by the advent of atomic power.

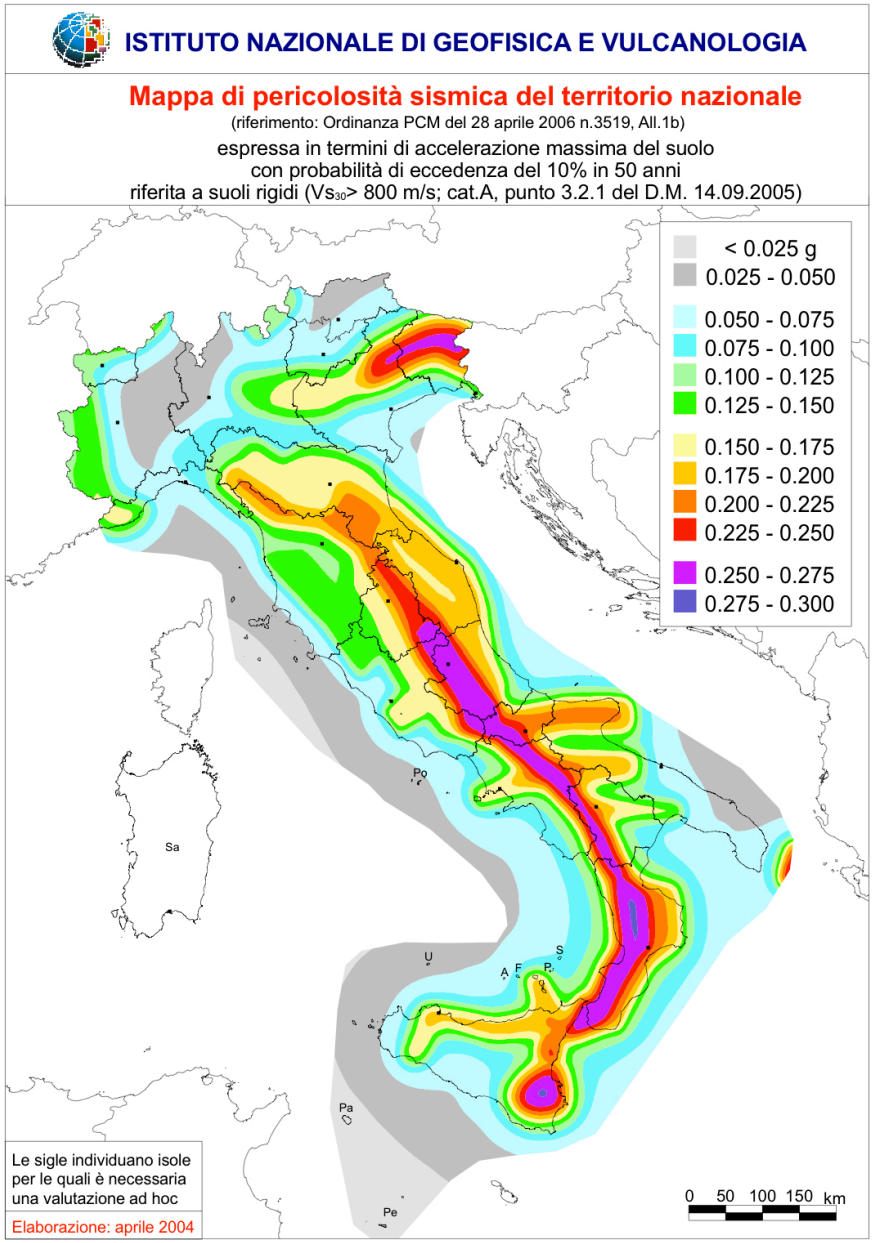
The example of Seismic Hazard

Seismic hazard (different time scales for different uses)

- **Long-term** (decades) is used for **the building code**
- **Medium term** (years) is used for prioritizing areas for retrofitting
- **Short-term** (days to weeks) is used to manage seismic sequences (before and after a mainshock) – presently under study...

Our best defense against earthquakes is to adopt appropriate building codes

Seismic hazard



Long-Term

The map shows ground motion values that have 10% of probability to be overcome in the next 50 years

Main purpose: Defining the building code for Italy (by law)

International Commission on Earthquake Forecasting (ICEF)

- Charged on 11 May 2009 by Dipartimento della Protezione Civile (DPC) to:
  1. Report on the current state of knowledge of short-term prediction and forecasting of tectonic earthquakes
  2. Indicate guidelines for utilization of possible forerunners of large earthquakes to drive civil protection actions
- ICEF report: ***"Operational Earthquake Forecasting: State of Knowledge and Guidelines for Utilization"***
  - Findings & recommendations released by DPC (Oct 2009) and endorsed by IASPEI (July 2011)
  - Final report published in *Annals of Geophysics* (Aug 2011)

Members (9 countries):

T. H. Jordan, Chair, USA

Y.-T. Chen, China

P. Gasparini, Secretary, Italy

R. Madariaga, France

I. Main, United Kingdom

W. Marzocchi, Italy

G. Papadopoulos, Greece

G. Sobolev, Russia

K. Yamaoka, Japan

J. Zschau, Germany

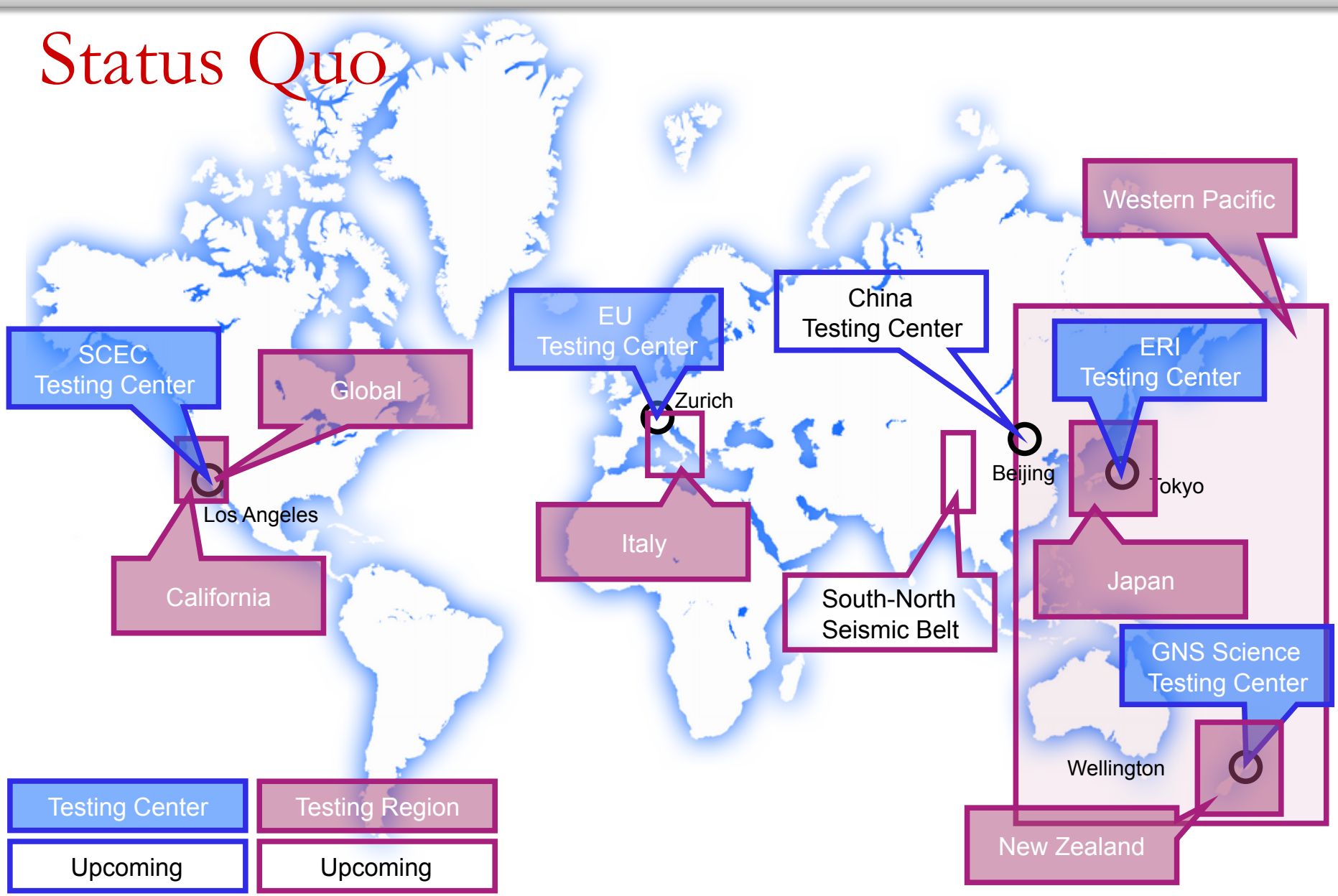
http://www.annalsofgeophysics.eu/index.php/annals/article/view/5350

Some issues on OEF...

- Seismic (and risk) hazard **varies with time** (in particular in the short-term)
- During a seismic sequence the weekly probability of a destructive earthquake can **increase 100-1000 times** with respect to the reference level (derived from the long-term hazard), but this **probability rarely reaches 1%**.
- Some of the available earthquake forecasting models are able to provide **accurate estimations of such probabilities** (verified through **CSEP** experiment)
- Despite the usual belief, such models are verified empirically **much better** than long-term hazard models.

Short-term seismic hazard: The L'Aquila earthquake legacy

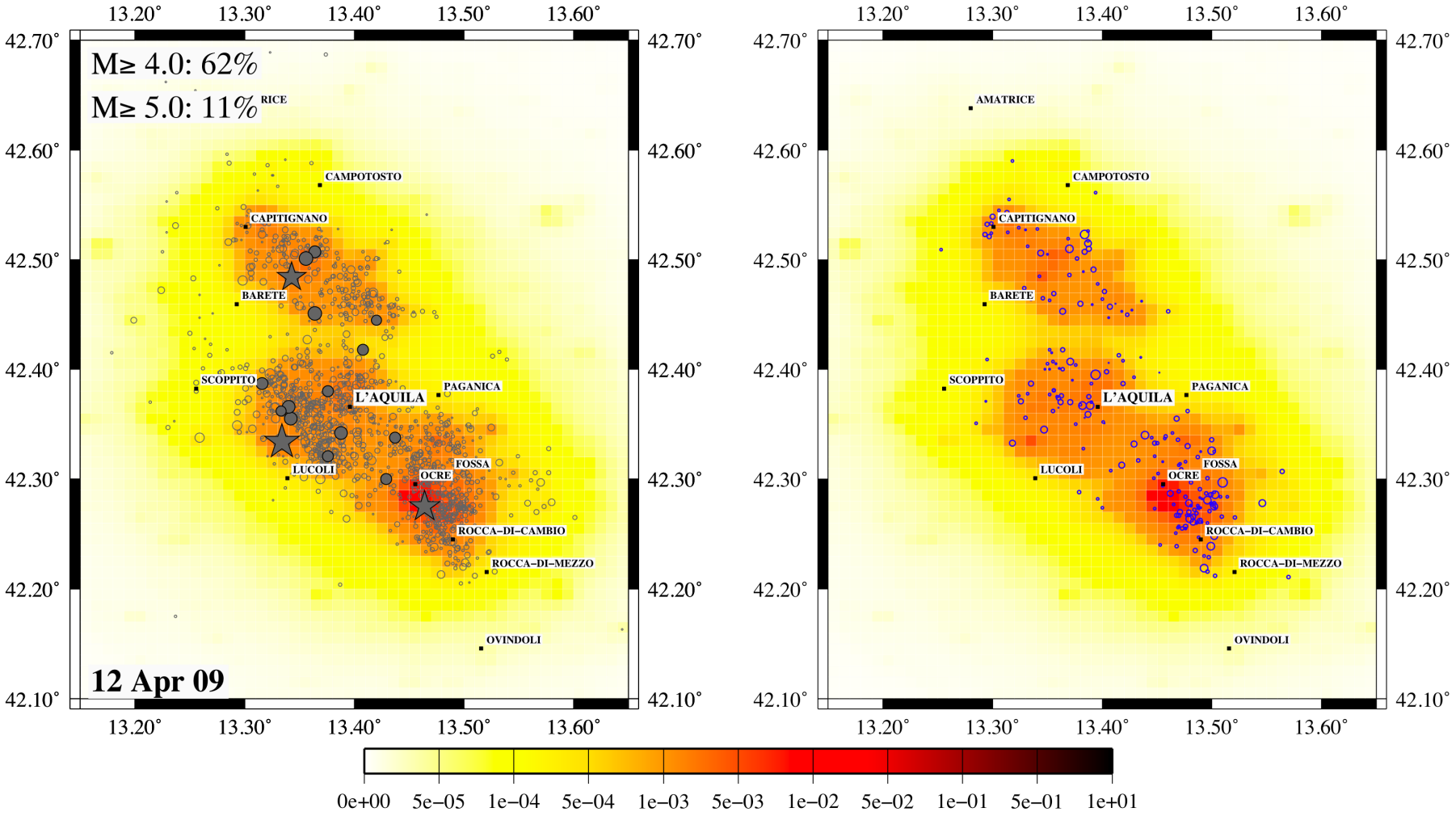
Status Quo



Short-term seismic hazard: The L'Aquila earthquake legacy

The 1-day forecasts *(the palette represents the rate of M 4+)*

Daily forecasts released at 8:00 AM (no overlaps)



Short-term seismic hazard: The L'Aquila earthquake legacy

- In most cases, the problem is approached establishing a probability threshold for each mitigation action based on cost/benefit analysis. These thresholds do not have any scientific meaning!

- The problem with OEF is that we are in a "low probability" environment, therefore, by definition the largest part of the mitigation actions will turn to be "false alarms".

- Personal perception and aversion of risk play a major role when the probabilities are low. (smoking cigarettes)

- Evacuation of a large number of people is never a rationale option

- There is not yet a best practice for decision making in this context

GEOPHYSICAL RESEARCH LETTERS, VOL. 37, L06306, doi:10.1029/2009GL042352, 2010

Click Here for Full Article

Are short-term evacuations warranted? Case of the 2009 L'Aquila earthquake

Thomas van Stiphout,[1] Stefan Wiemer,[1] and Warner Marzocchi[2]

Received 31 December 2009; revised 6 February 2010; accepted 19 February 2010; published 26 March 2010.

[1] The disastrous earthquake in L'Aquila Italy (Mw 6.3, 6 April 2009) again highlights the issue of potentially reducing seismic risk by releasing warnings or initiating mitigation actions. Earthquakes cluster strongly in space and time, leading to periods of increased seismic hazard. During such seismic crises, seismologists typically convey their knowledge of earthquake clustering based on past experience, basic statistics and "gut feeling." However, this information is often not quantitative nor reproducible and difficult for decision-makers to digest. We define a novel interdisciplinary approach that combines probabilistic seismic hazard and risk assessment with cost-benefit analysis to allow objective risk-based decision-making. Our analysis demonstrates that evacuation as mitigation action is rarely cost-effective. Future mitigation strategies should target the weakest buildings and those on the poorest soil.
Citation: van Stiphout, T., S. Wiemer, and W. Marzocchi (2010), Are short-term evacuations warranted? Case of the 2009 L'Aquila earthquake, *Geophys. Res. Lett.*, *37*, L06306, doi:10.1029/2009GL042352.

[3] Currently, it is believed that a "foreshock" is physically indistinguishable from any other earthquake, until a subsequent "mainshock" retroactively marks it as special [*Christophersen and Smith*, 2008; *Felzer et al.*, 2004; *Reasenberg*, 1999]. Therefore, seismologists are constrained to using probabilistic models to translate knowledge on earthquake clustering for the benefit of the society.

[4] A typical statement that seismologists make to the public, media and decision-makers after the occurrence of a moderate earthquake is: "It is possible but unlikely that this event will be followed by a subsequent larger event in the next few days." In regions, such as California, Italy and Japan, quantitative "aftershock" probabilities are calculated [*Gerstenberger et al.*, 2005; *Marzocchi and Lombardi*, 2009]. In rare instances, based on these calculations, authorities issue a statement of increased probability, such as recently done by the California Earthquake Prediction Evaluation Council on 24 March 2009, when swarm-like activity near Bombay Beach was punctuated by a M_w4.8 earthquake. The panel reported (based on the work by *Agnew*

So, is OEF & decision making a worthwhile effort?

As a citizen, **I do think YES**, it is.

A possible solution: **communication** and **education**

If you think **no**, ask to yourself if...

- Is it important to communicate the **risk from smoking**?
- Would you like to know the risk associated with a specific **medicine** or **clinical analysis**?
- Would you **fly** with a probability of 0.1% to have a **crash**?
- Many other examples ...

Advisory on individual mitigating actions (**nudges**)

- As with political risk, if your travel to a region where **the risk is increased** is discretionary and not essential, you may wish to reconsider.
- If your home or workplace is in one of these regions, and is **seismically vulnerable** (e.g. collapse-prone), you and/or your employer may wish to take action to reduce your risk.
- If you live in this region, and spend time in **seismically vulnerable** buildings, you may wish to take action to reduce your exposure.
- Many others ...

The future challenges

- Scientists have to express all known uncertainties using probabilities

- Decision makers have to plan decision making strategies based on uncertain scientific information. **NEED OF PROTOCOLS**

- We need to understand the best way to communicate uncertainties, in particular large uncertainties (small probabilities)

- Every citizens has to become aware that we live in a risky world. **Education and information** are the pillars for any kind of successful decision making strategy: both at a societal and personal level

- Every citizens has to become familiar with the concept of probability.

There are not ***right*** or ***wrong*** decisions.
There are decisions that are **rationale and defensible**.
Others aren’t.

"Don't judge human action by what happens"
J. Bernoulli

Thanks!

warner.marzocchi@ingv.it