Master Degree Programme in Physics - UNITS
Physics of the Earth and of the Environment

Seismic (and volcanic) Risk

FABIO ROMANELLI

Department of Mathematics & Geosciences

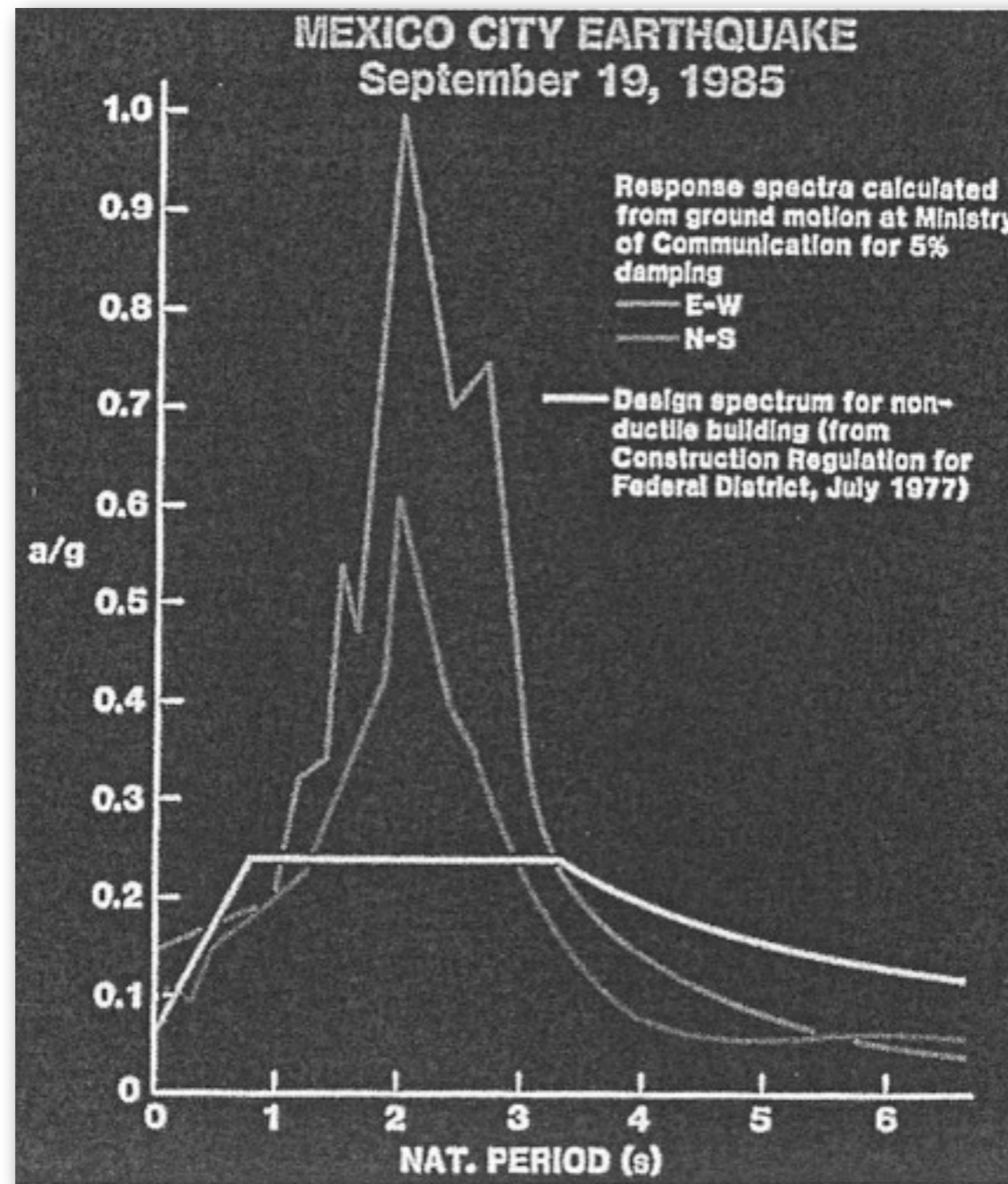romanel@units.it

UNIVERSITÀ
DEGLI STUDI DI TRIESTE

the road to (earthquake) safety...

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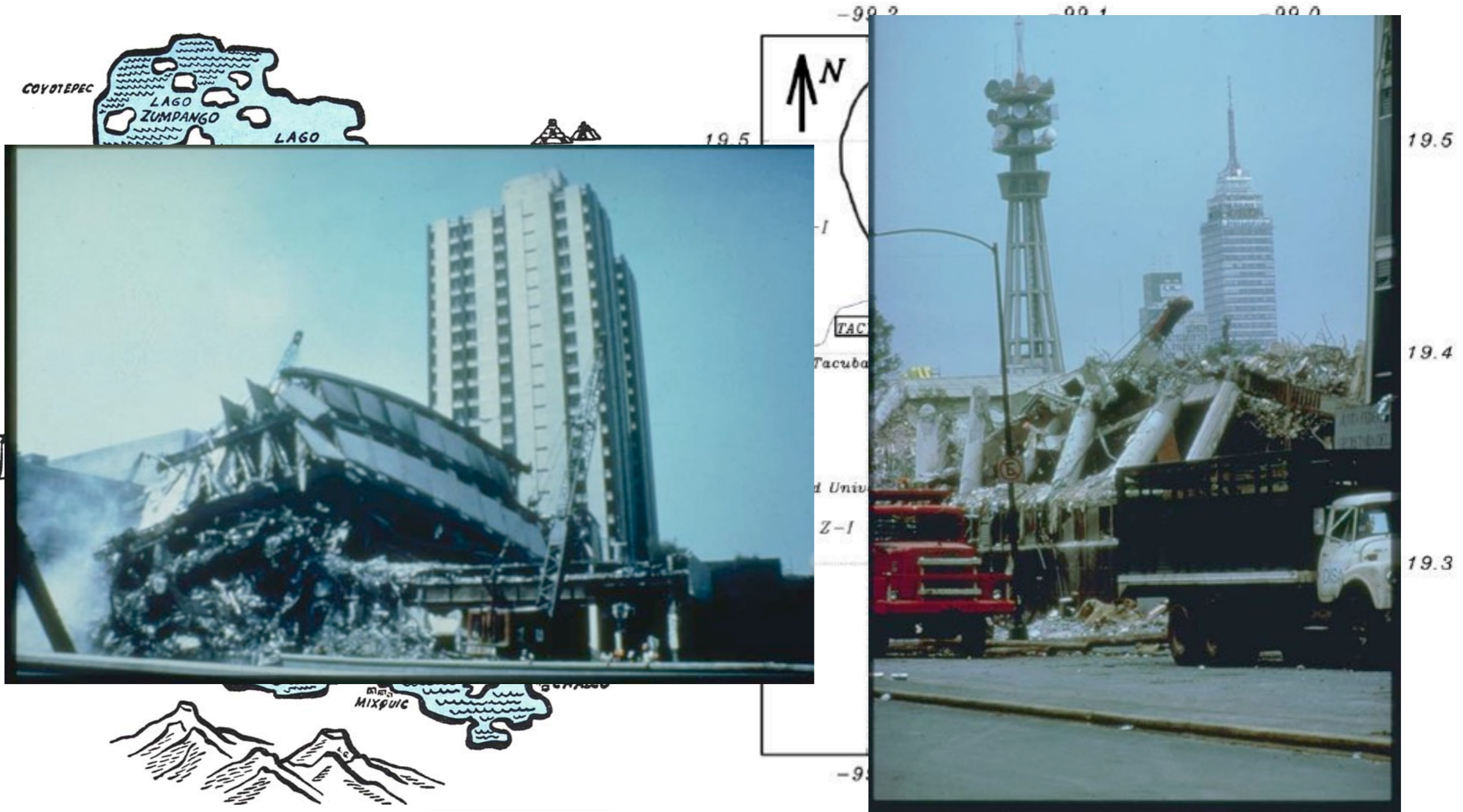
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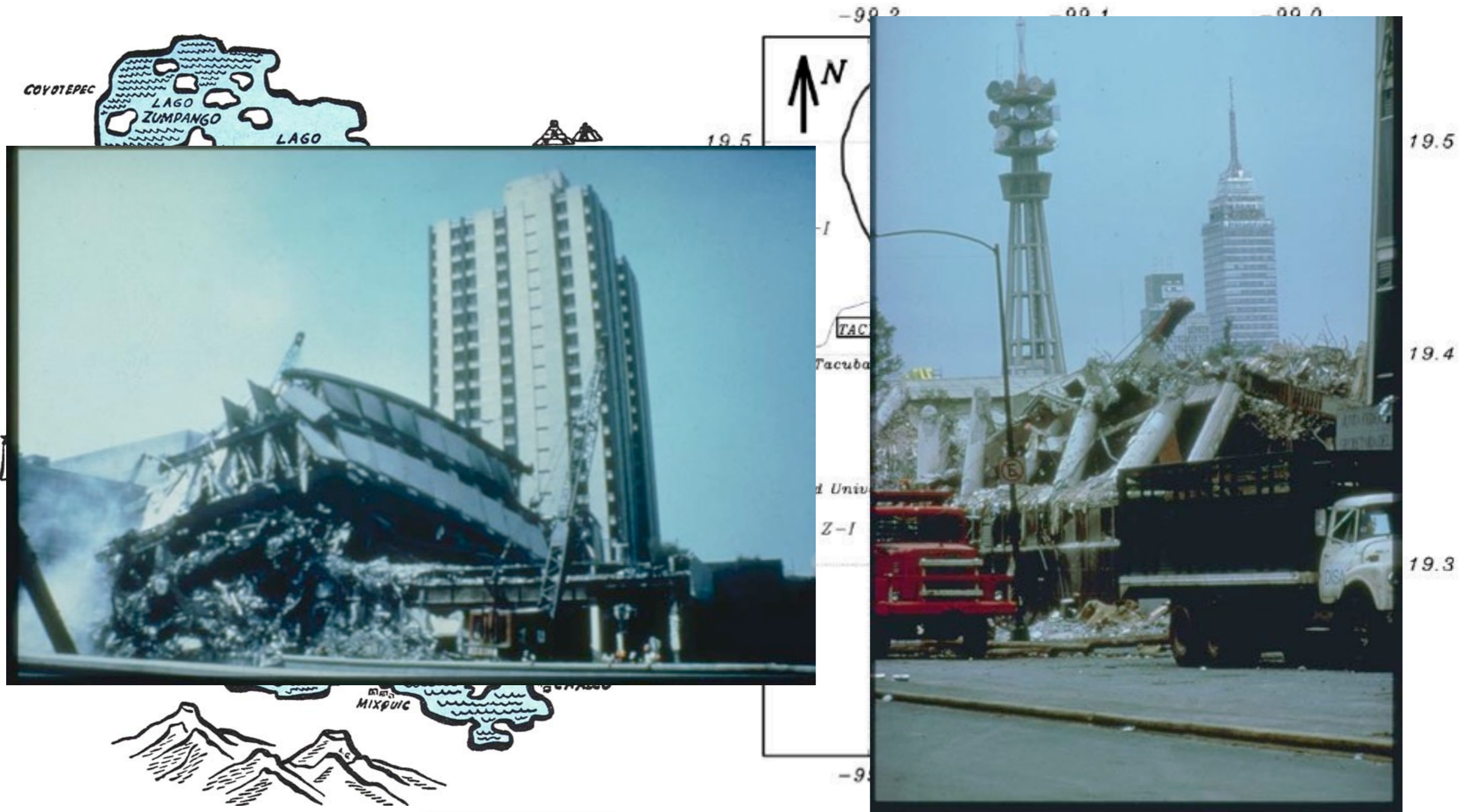
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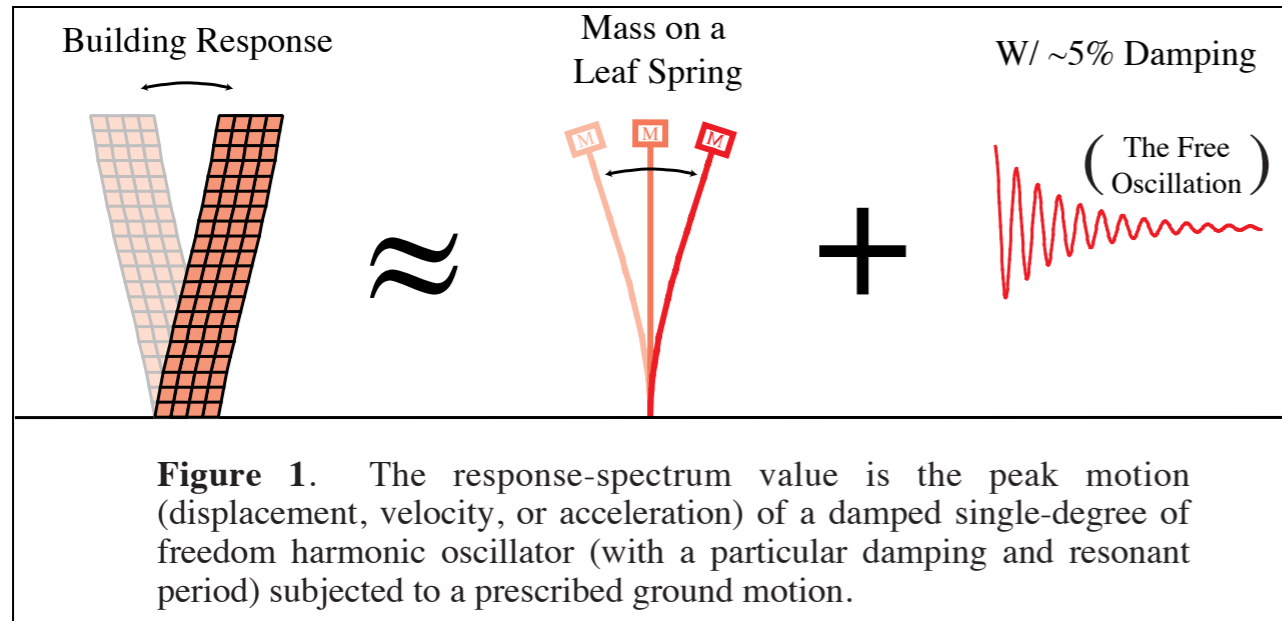

Mitigate the difference...

Response spectra

Figure 1. The response-spectrum value is the peak motion (displacement, velocity, or acceleration) of a damped single-degree of freedom harmonic oscillator (with a particular damping and resonant period) subjected to a prescribed ground motion.
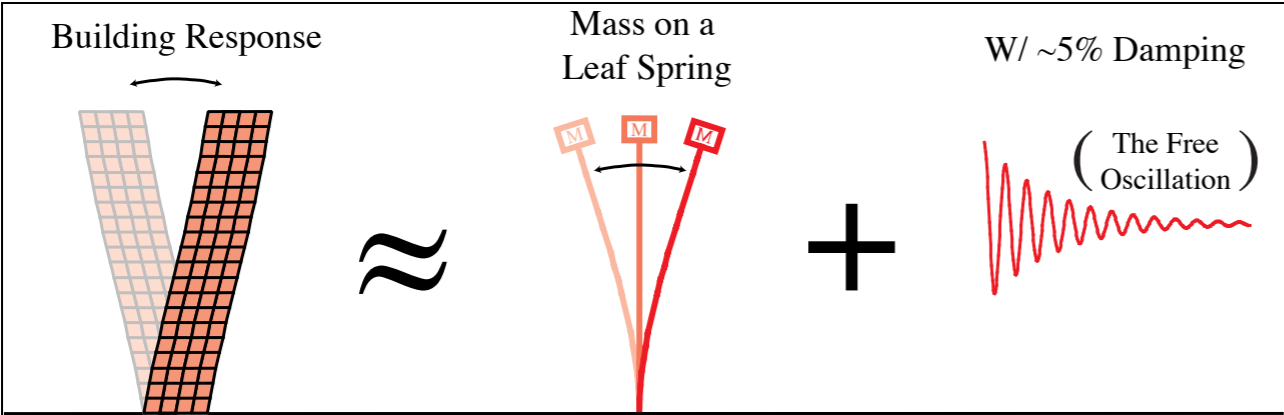
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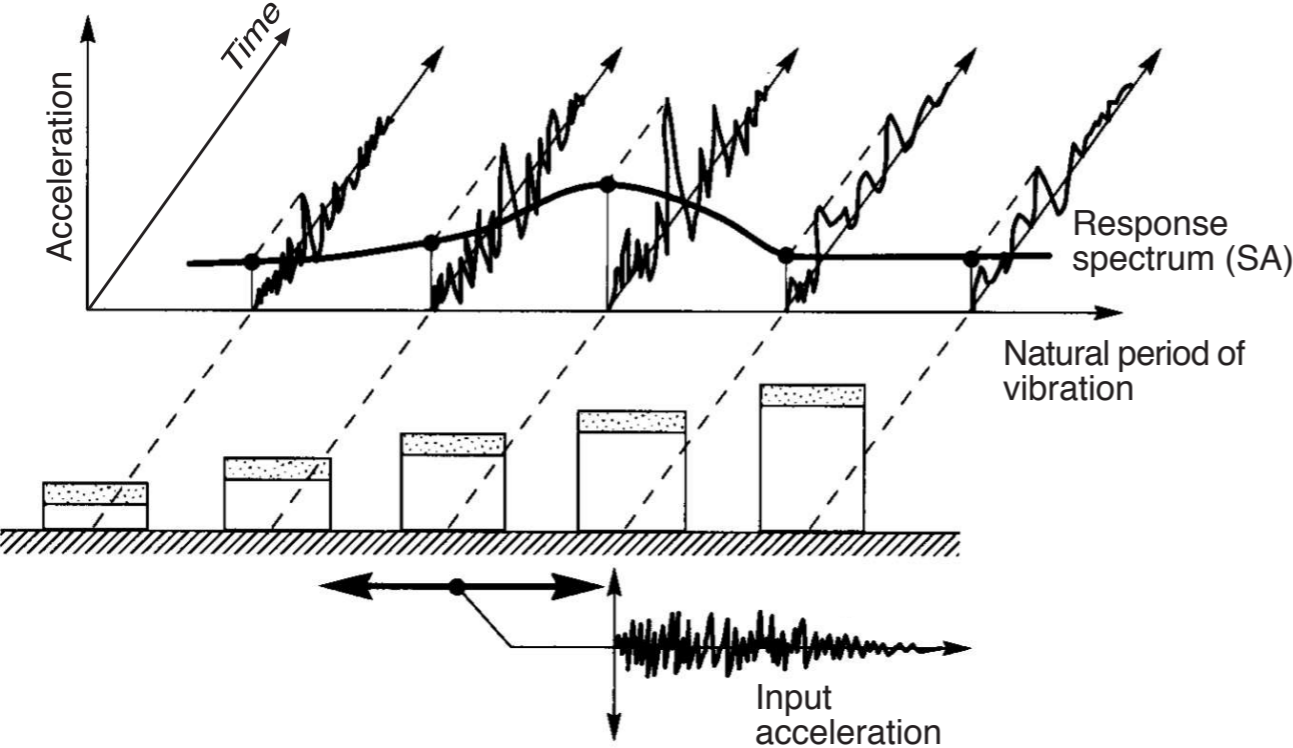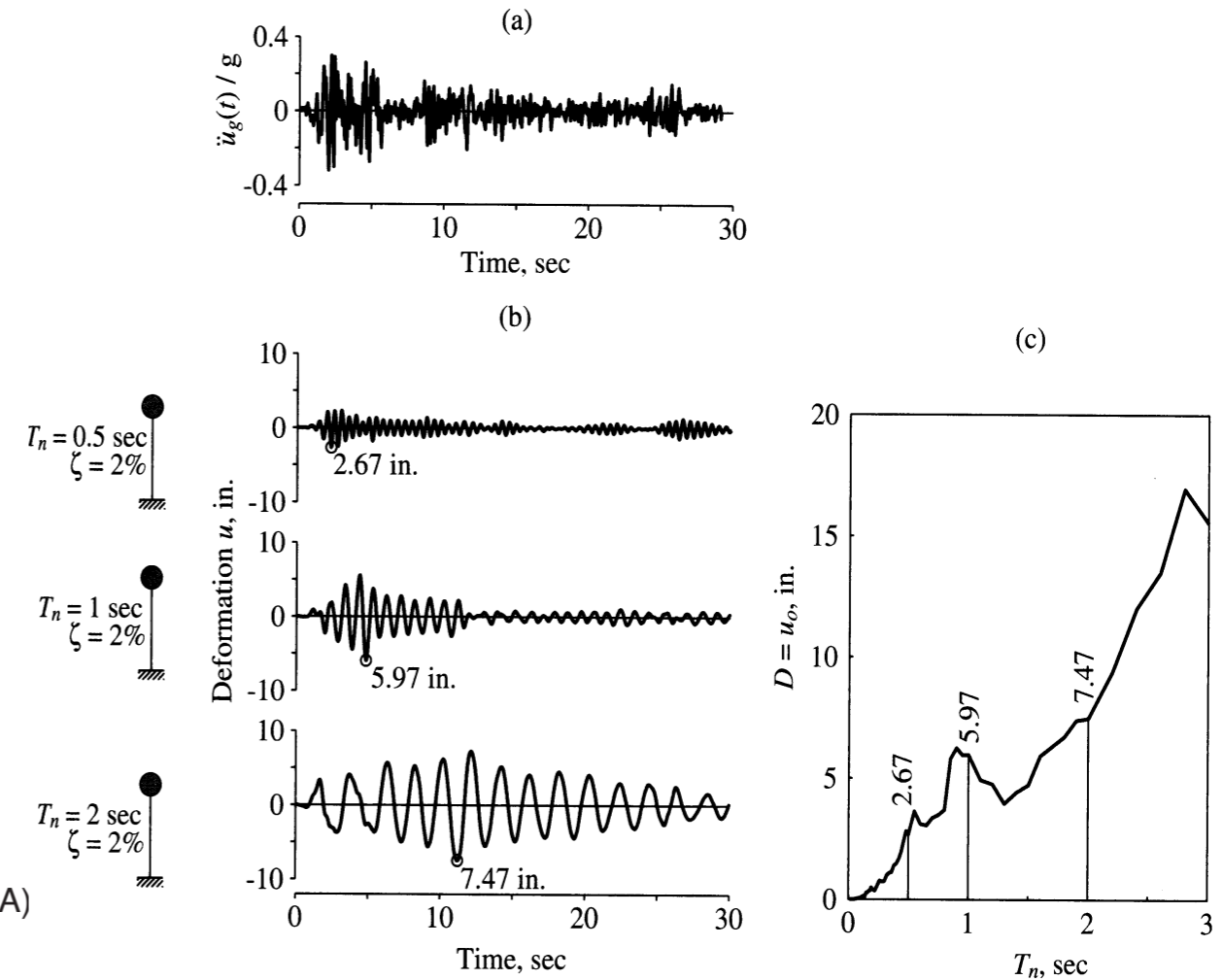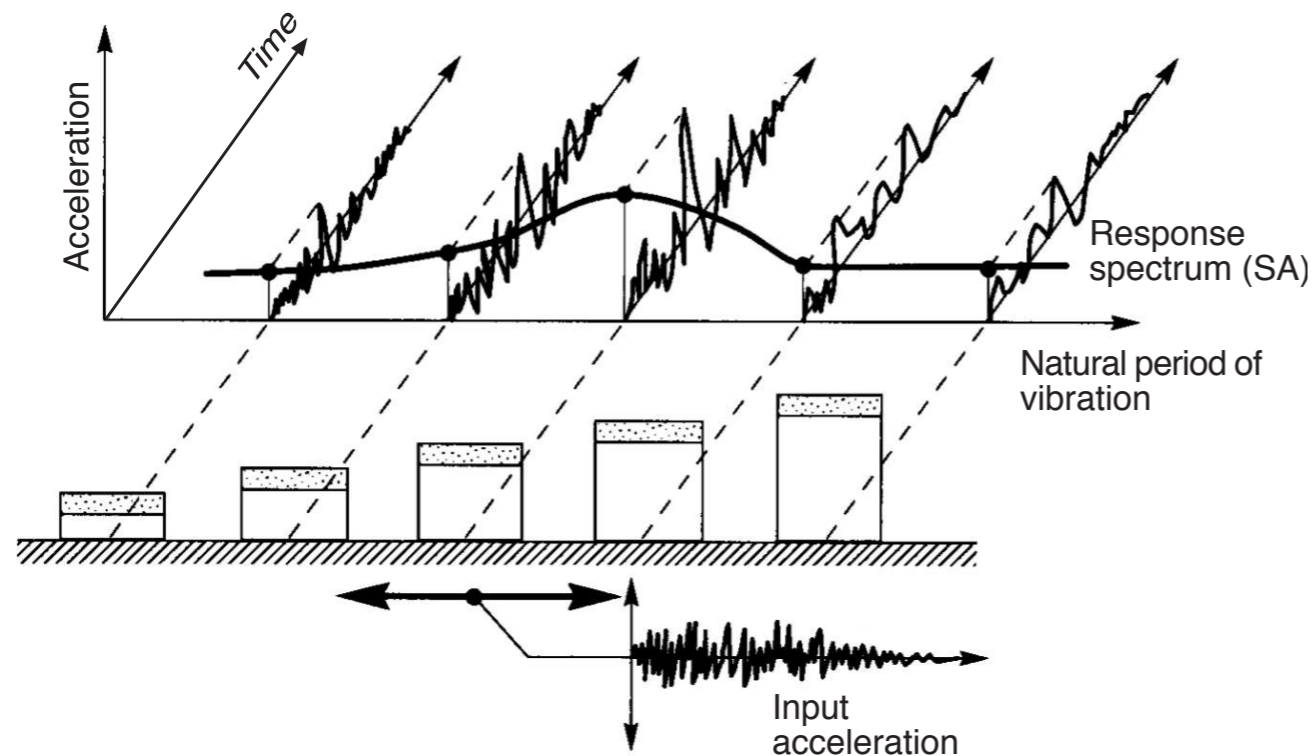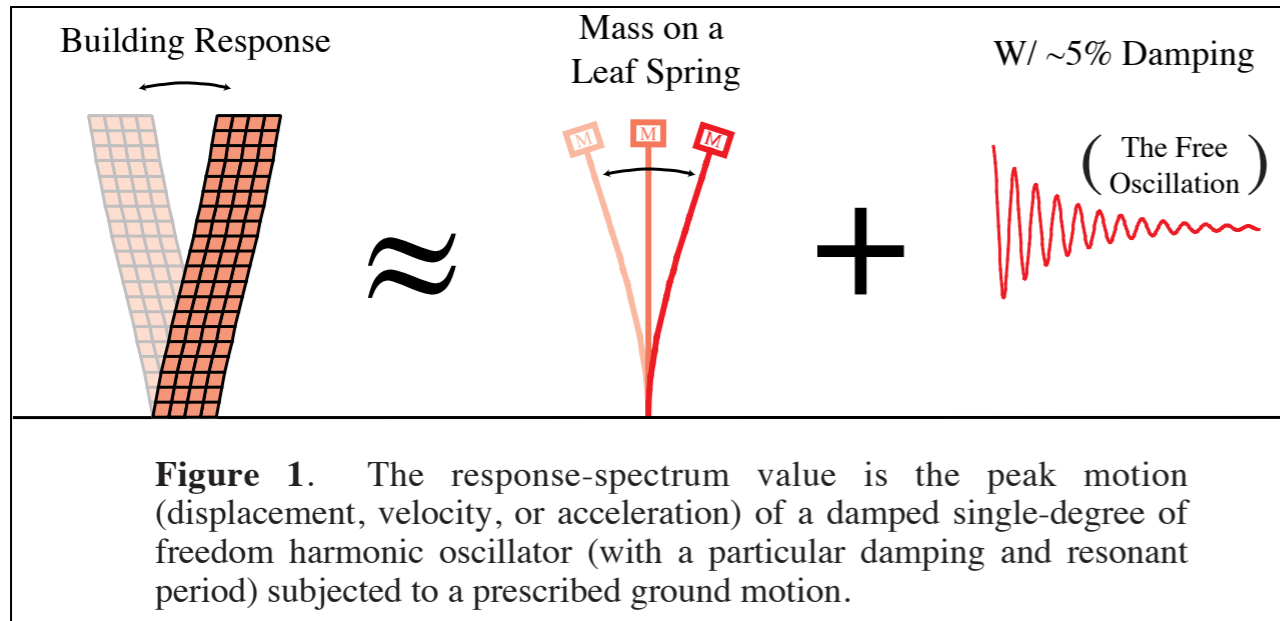
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Building Response

Mass on a Leaf Spring

W/ ~5% Damping

$\left(\begin{array}{c}\text{The Free}\\\text{Oscillation}\end{array}\right)$

Acceleration

Time

Response spectrum (SA)

Natural period of vibration

Input acceleration

$\ddot{u}_g(t)$ / g

(a)

Time, sec

(b)

$T_n = 0.5$ sec
$\zeta = 2\%$

2.67 in.

$T_n = 1$ sec
$\zeta = 2\%$

5.97 in.

$T_n = 2$ sec
$\zeta = 2\%$

7.47 in.

Deformation u, in.

Time, sec

(c)

$D = u_o$, in.
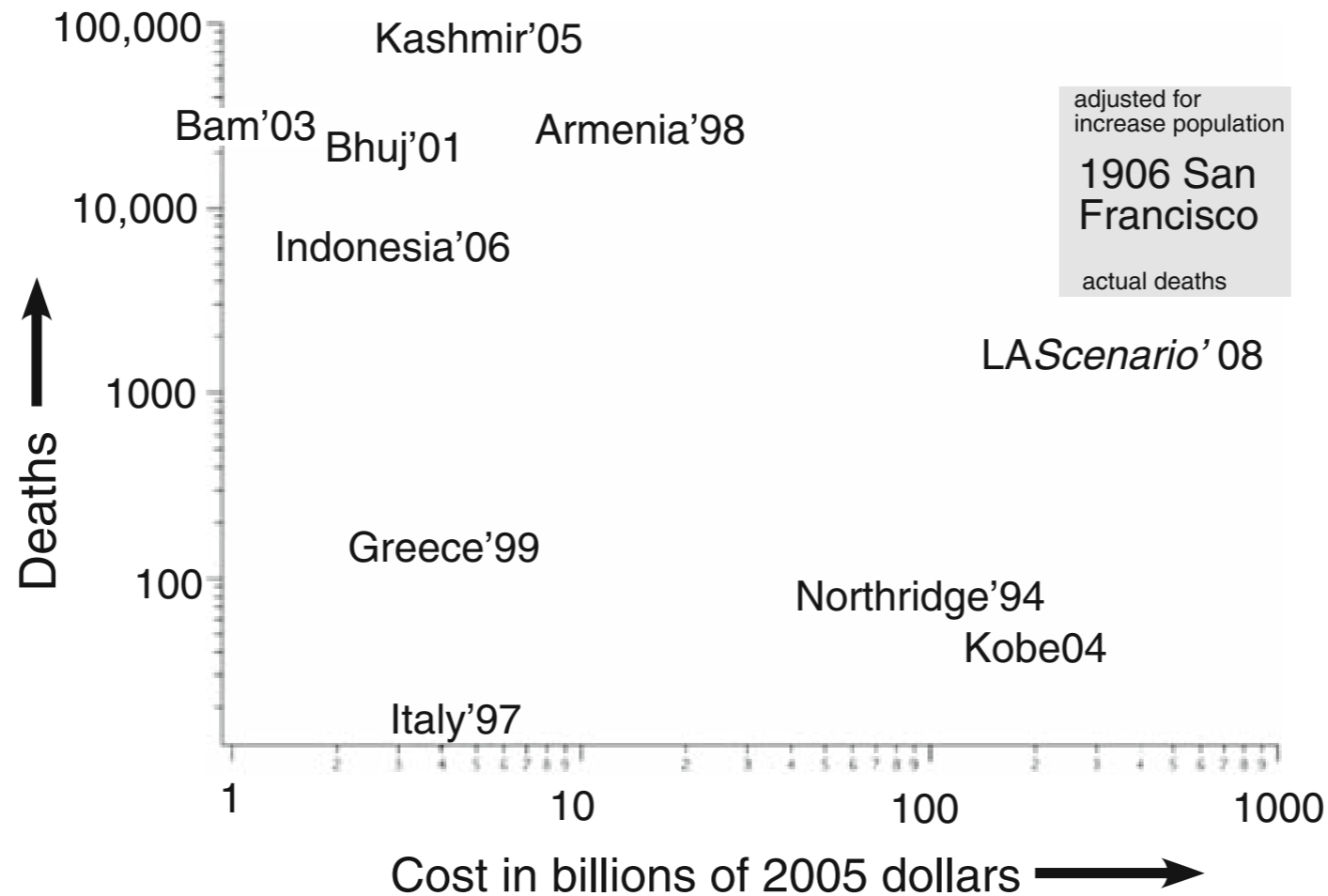
2.67

5.97

7.47

T_n, sec

Figure 6.6.1 (a) Ground acceleration; (b) deformation response of three SDF systems with $\zeta = 2\%$ and $T_n = 0.5$, 1, and 2 sec; (c) deformation response spectrum for $\zeta = 2\%$.

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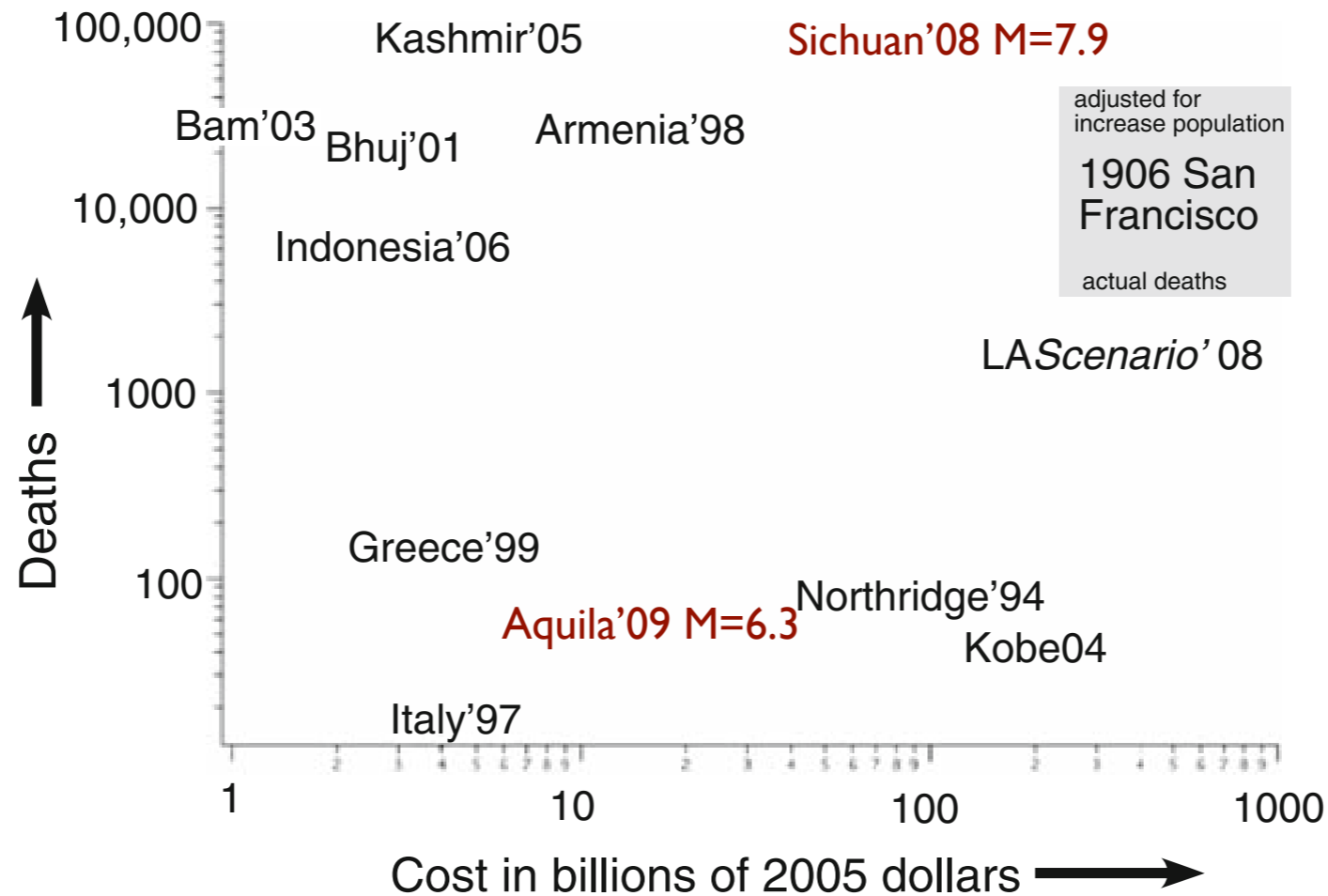## Know the input - Bound the output...

Earthquake fatalities versus repair costs in 2005 US$

Bilham, 2009. The seismic future of cities, Bull Earthquake Eng.
Roughly updated with help of Bilham, 2010 (Personal communication)

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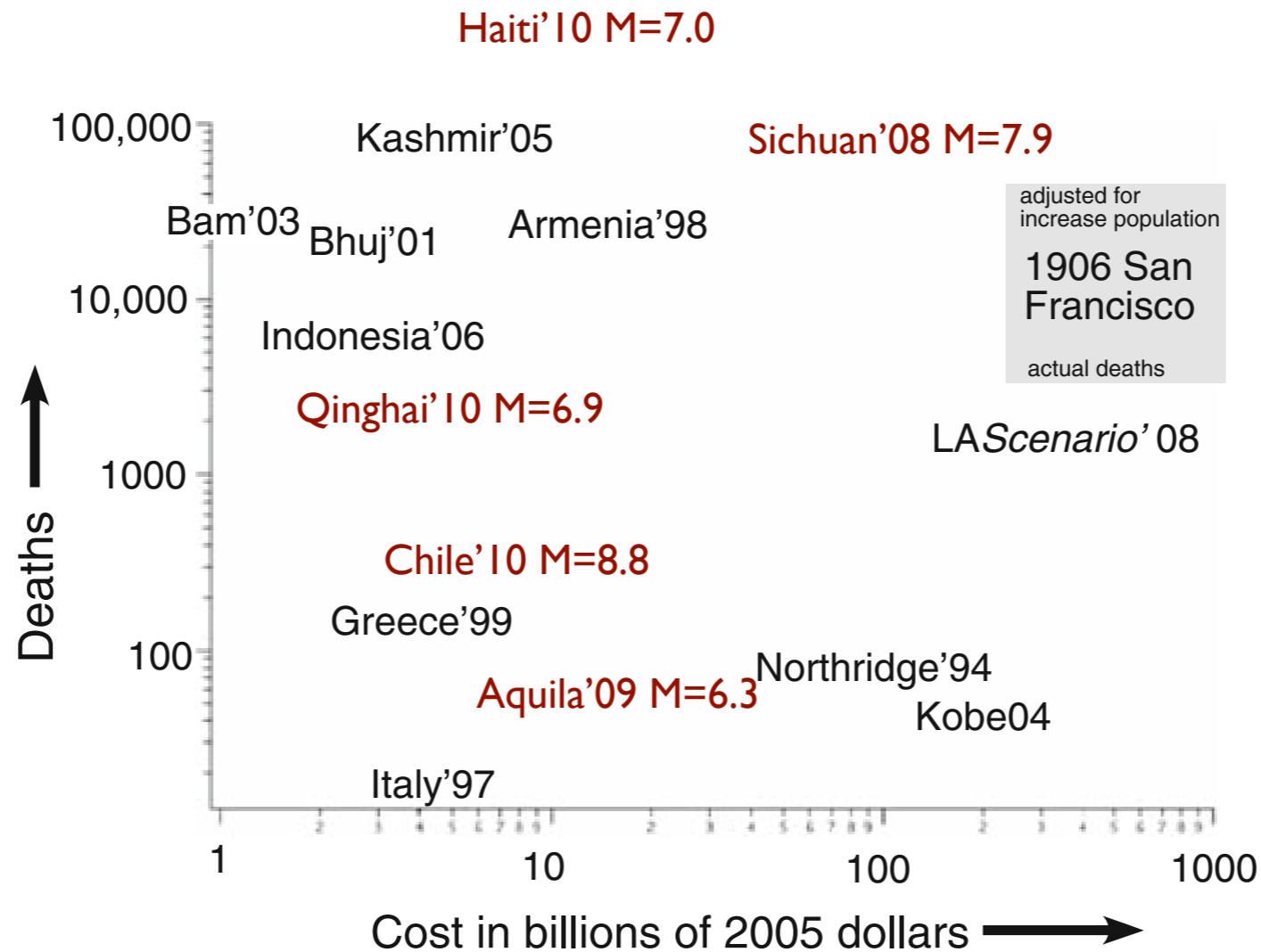Earthquake fatalities versus repair costs in 2005 US$

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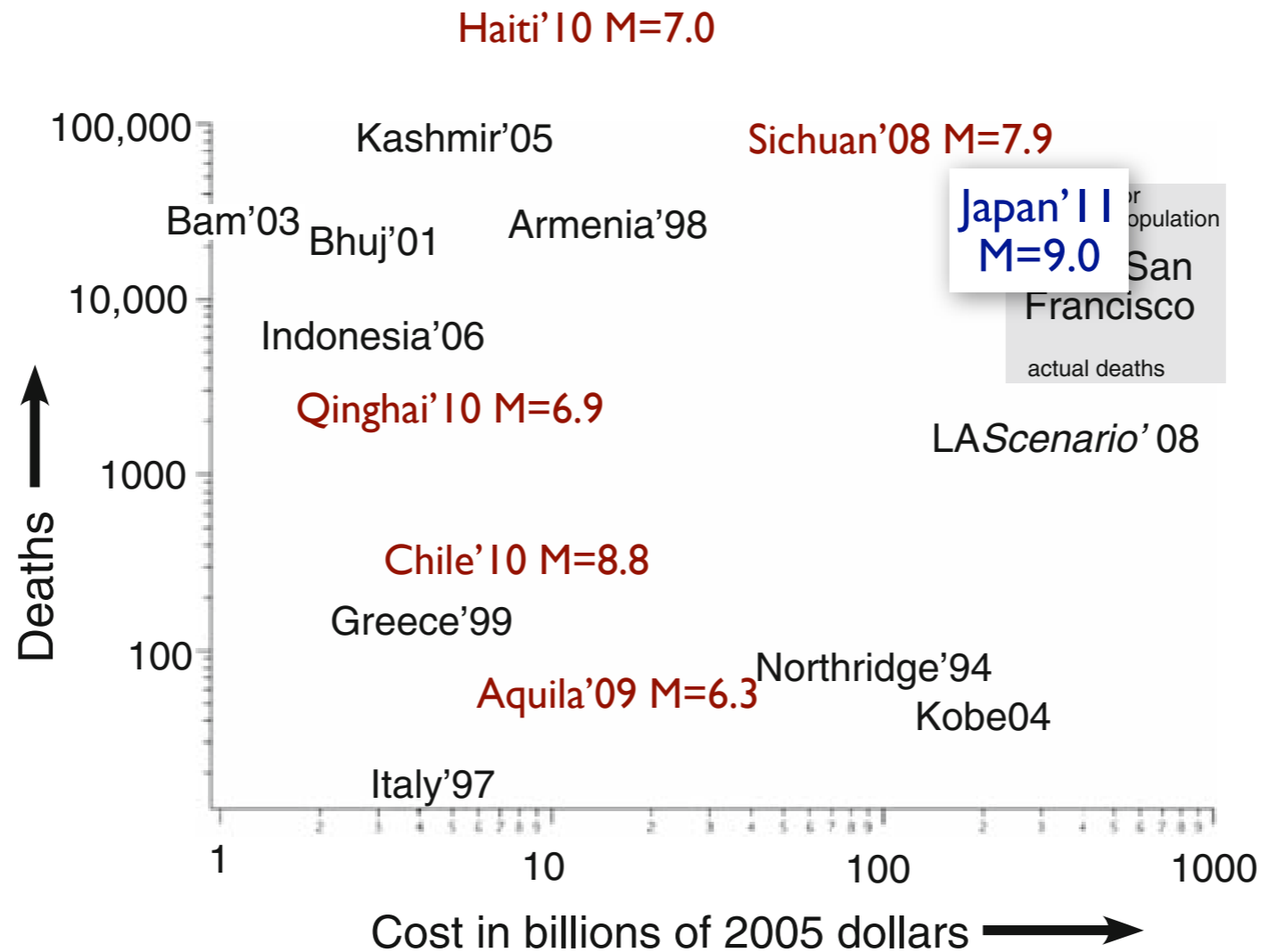
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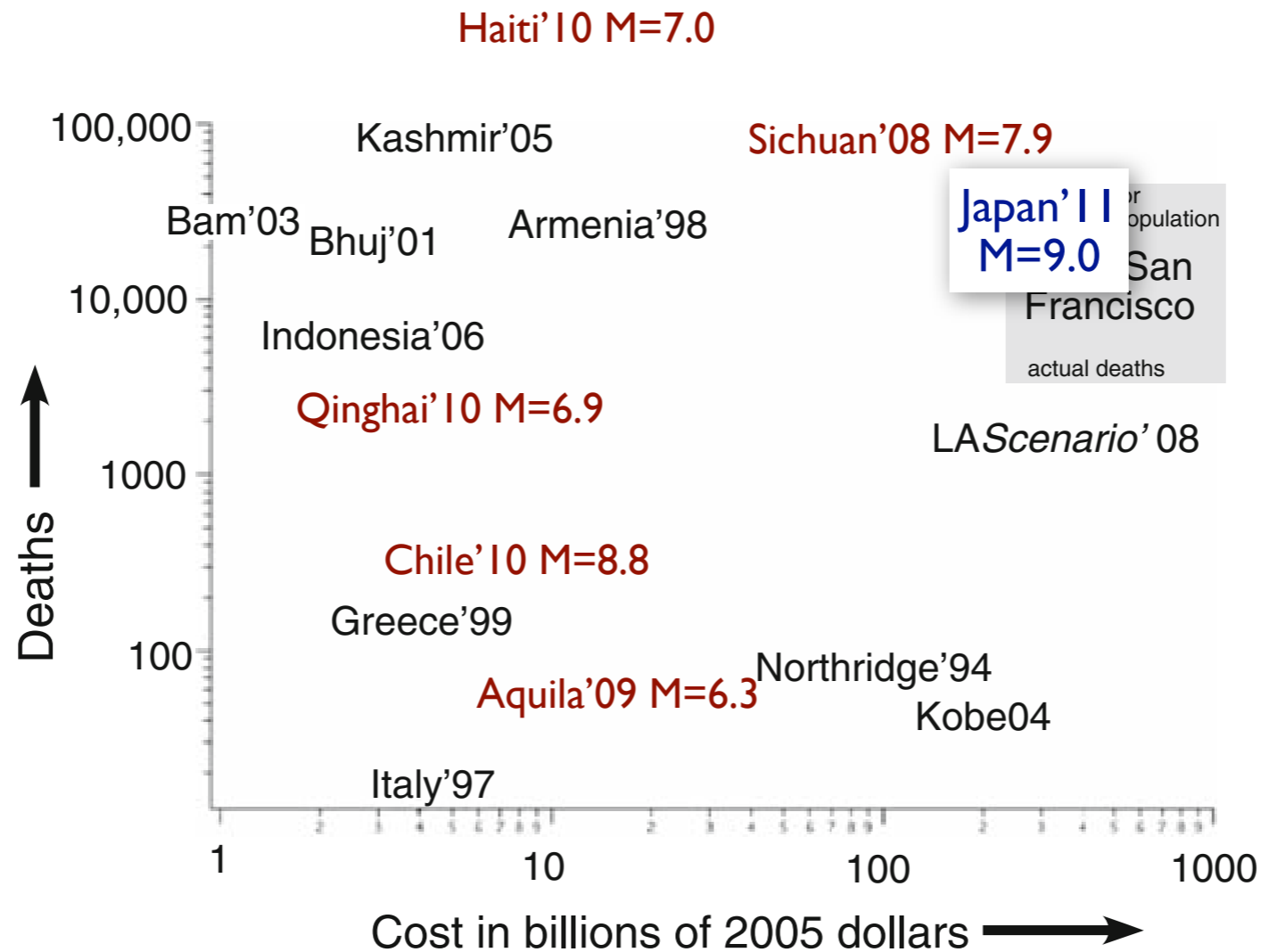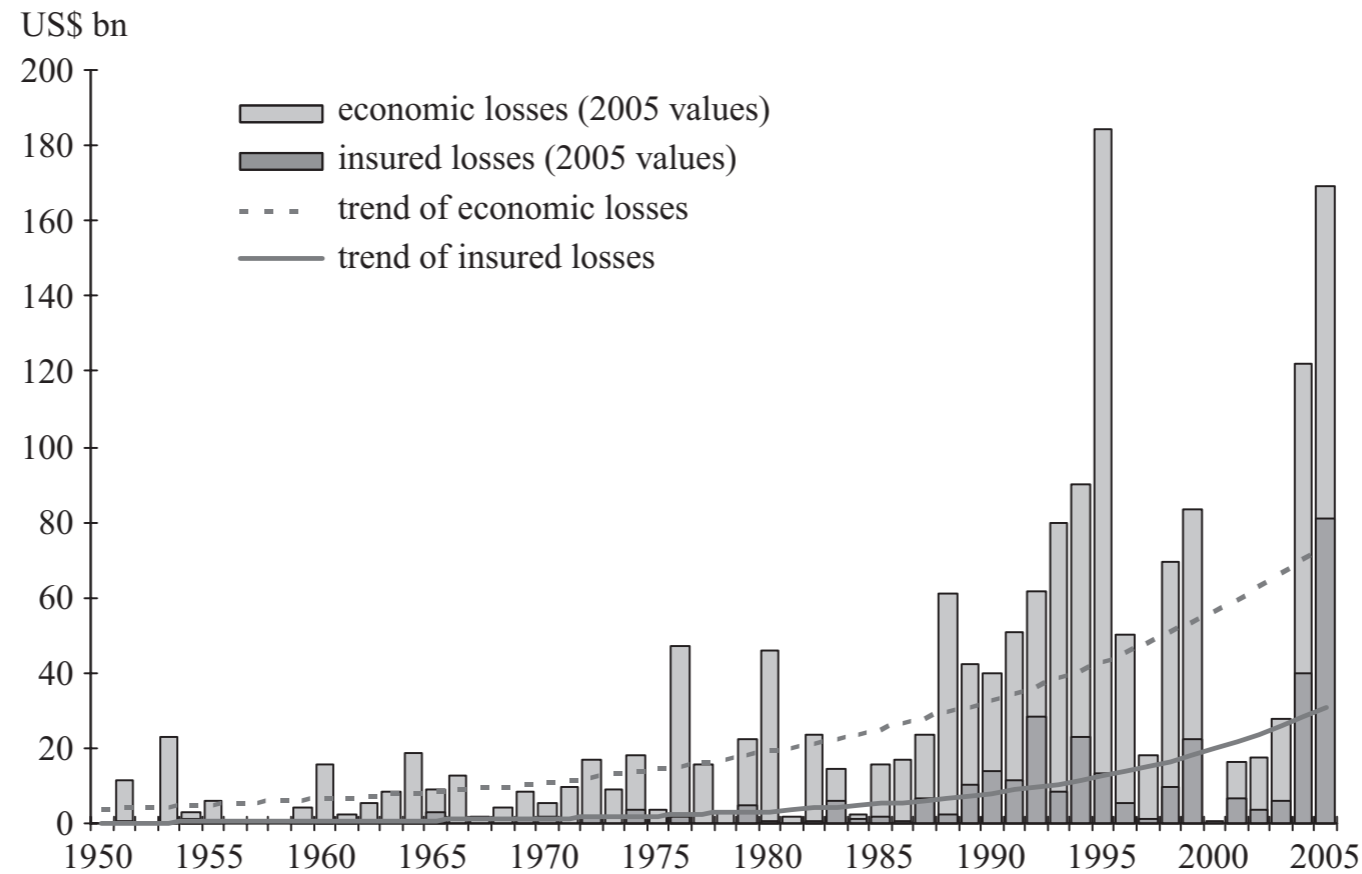Earthquake fatalities versus repair costs in 2005 US$

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Mitigate the difference...

Losses from great natural disasters...

Losses from great natural disasters
(far exceeding 100 deaths or US$ 100 m in losses), 1950–2005

Smolka, 2006.
Natural disasters and the challenge of extreme events: risk management from an insurance perspective, Phil. Trans. R. Soc.

Some basic definitions:

- Seismic Hazard: describes the potential for dangerous, earthquake related phenomena, such as ground shaking, fault rupture or soil liquefaction.

- Seismic Risk: probability of occurrence of these consequences.

Reiter, 1990

Some basic definitions

- 🔴 Seismic Hazard: any physical phenomenon (e.g. shaking) associated with an earthquake that may cause an adverse effect on human activity.

- 🔴 Seismic Risk: a probability that social or economic consequences will exceed a specified value.

Anderson, 2006

Some basic definitions

- **Seismic Hazard:** a physical effect associated with an earthquake, such as ground shaking, that MAY produce adverse effects.

- **Seismic Risk:** the probability that consequences of an earthquake, such as structural damage, will equal or exceed specified values in a specified period of time.

Ventura, 2006

Hazard, Risk & Vulnerability

$$\text{Risk} = \text{Hazard} * \text{Vulnerability}$$

Hazard, Risk & Vulnerability

Risk = Hazard * Vulnerability

Nature decided, and can be assessed

Hazard, Risk & Vulnerability

Risk = Hazard * Vulnerability

Nature decided, and can be assessed

Man decided, and can be reduced

Hazard, Risk & Vulnerability

Risk = Hazard * Vulnerability

Nature decided, and can be assessed

Man decided, and can be reduced

$$R = \langle H_i, P_i, C_i \rangle$$

set of i-events with possible adverse consequences

associated probabilities of their occurrence

associated intolerable consequences