UNIVERSITÀ DI TRENTO

Trento, 03 February 2023
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Lecture #4

Probabilistic Seismic Risk Analysis for building and industrial systems

Chiara Nardin – Ph.D., M.Sc., Eng. in Civil Engineering

https://github.com/CNardin

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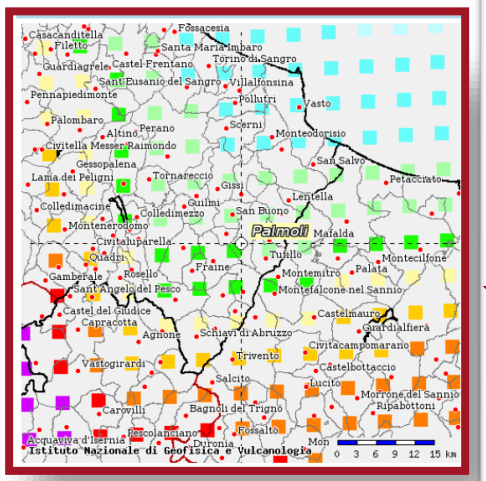
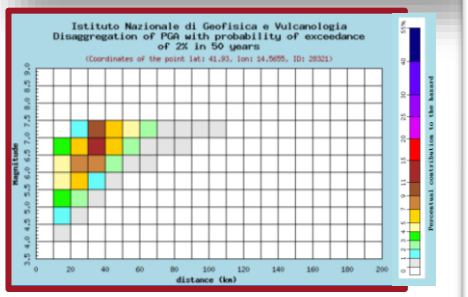
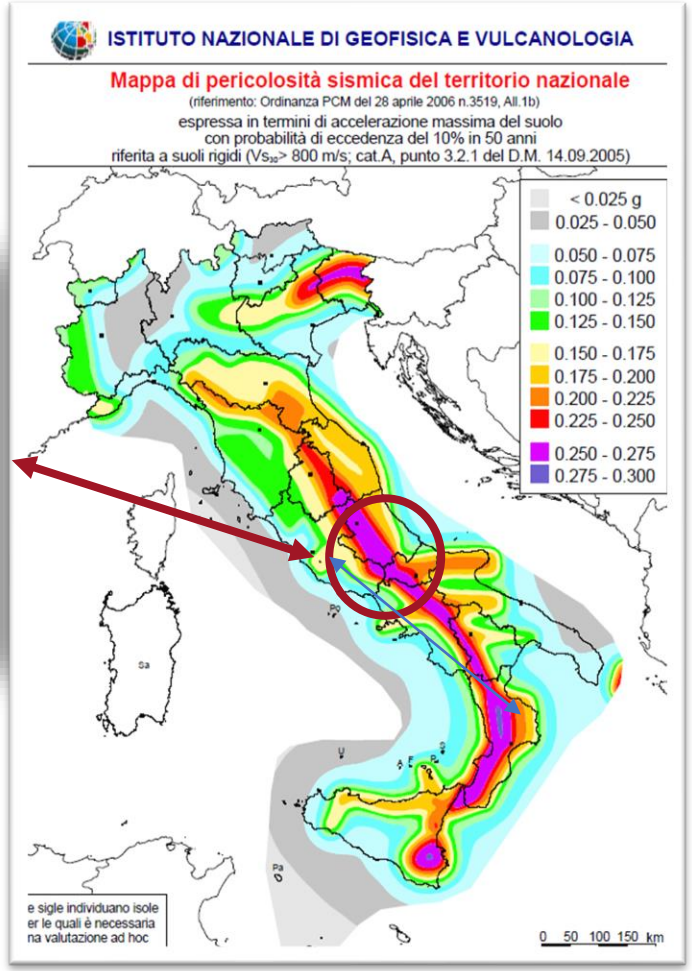
Outline:

- Motivations: earthquake and losses
- Hazard curves and fragility functions
- PBEE-PEER framework
- Lecture Plan







http://zonesismiche.mi.ingv.it/

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seismic risk

«Risk has been defined, for management purposes, as the potential economic, social and environmental consequences of hazardous events that may occur in a specified period of time. »

Seismic risk evaluation for an urban centre, M.L.**Carreno**, O.D.**Cardona**, A.H.**Barbat**, 250th Anniversary of the 1755 Lisbon Earthquake

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seismic risk ≠ seismic hazard

«A seismic hazard is the probability that an earthquake will occur in a given geographic area, within a given window of time, and with ground motion intensity exceeding a given threshold. »

Probabilistic seismic hazard analysis: Early history, **McGuire,** R. Earthquake Engng Struct. Dyn., *2008*

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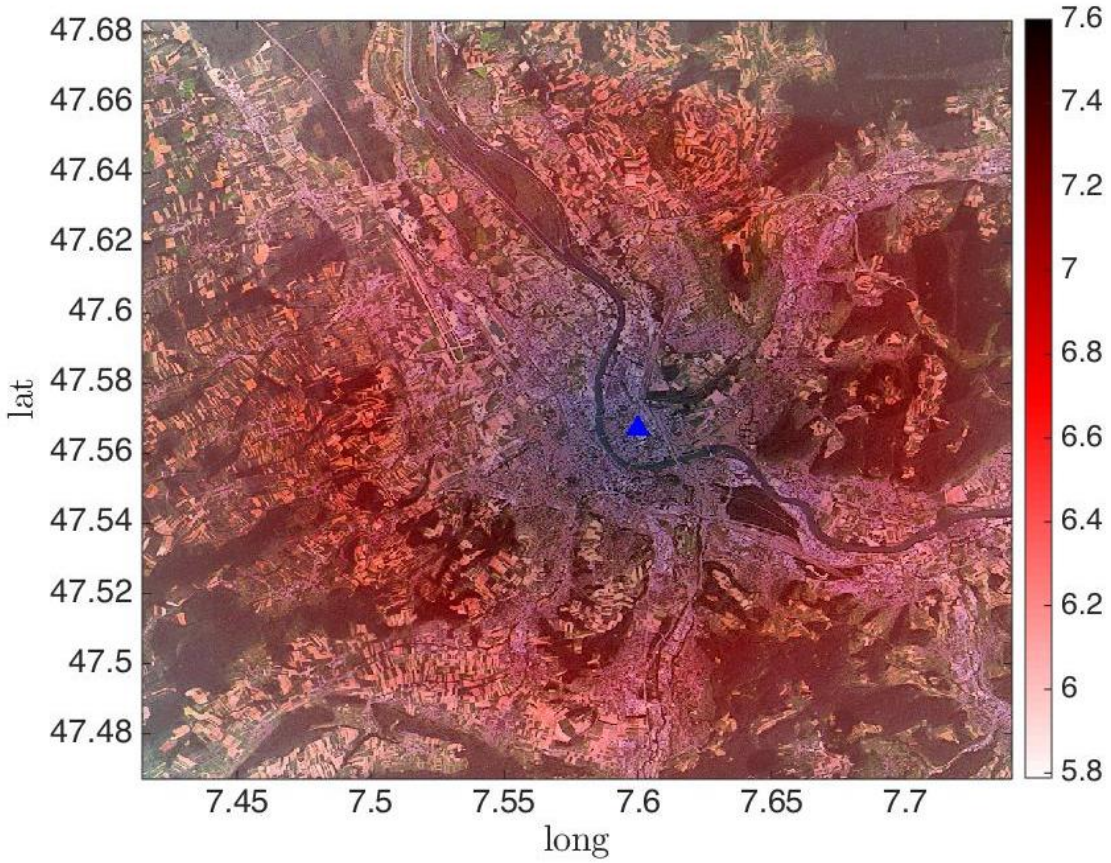

hazard map

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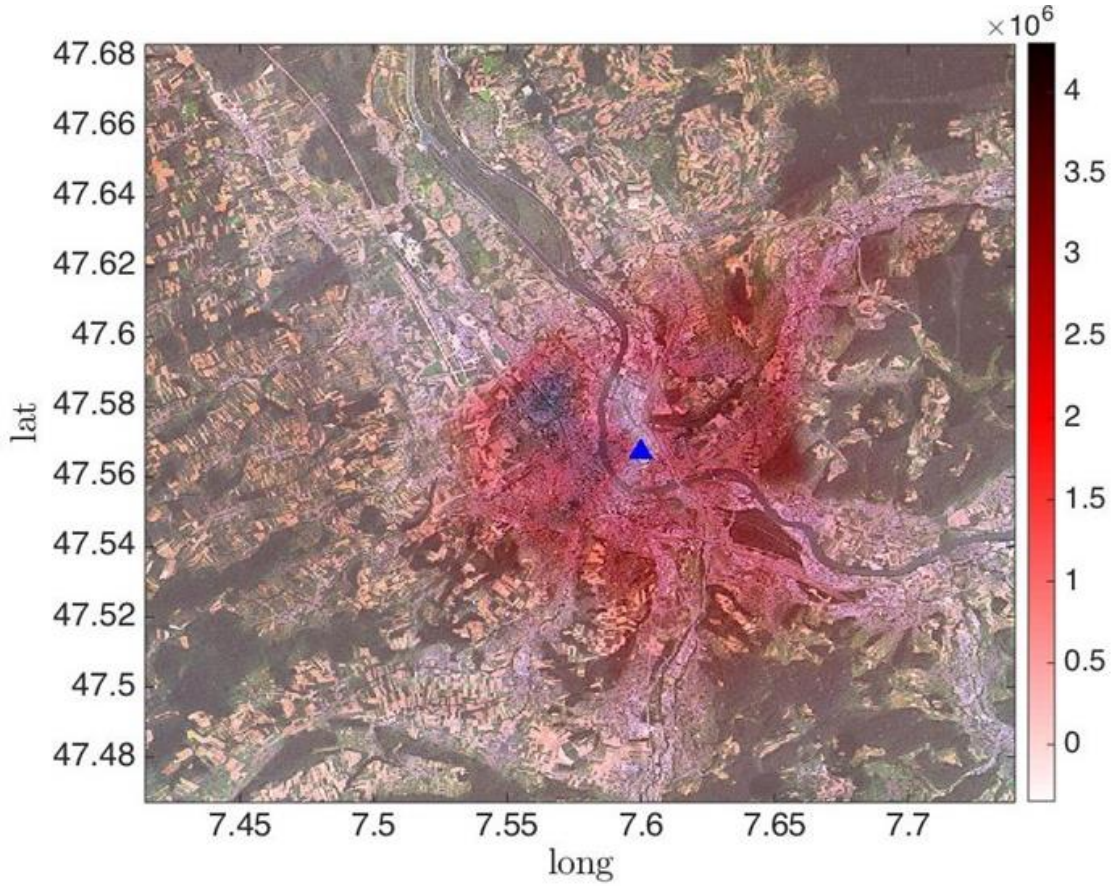

risk map

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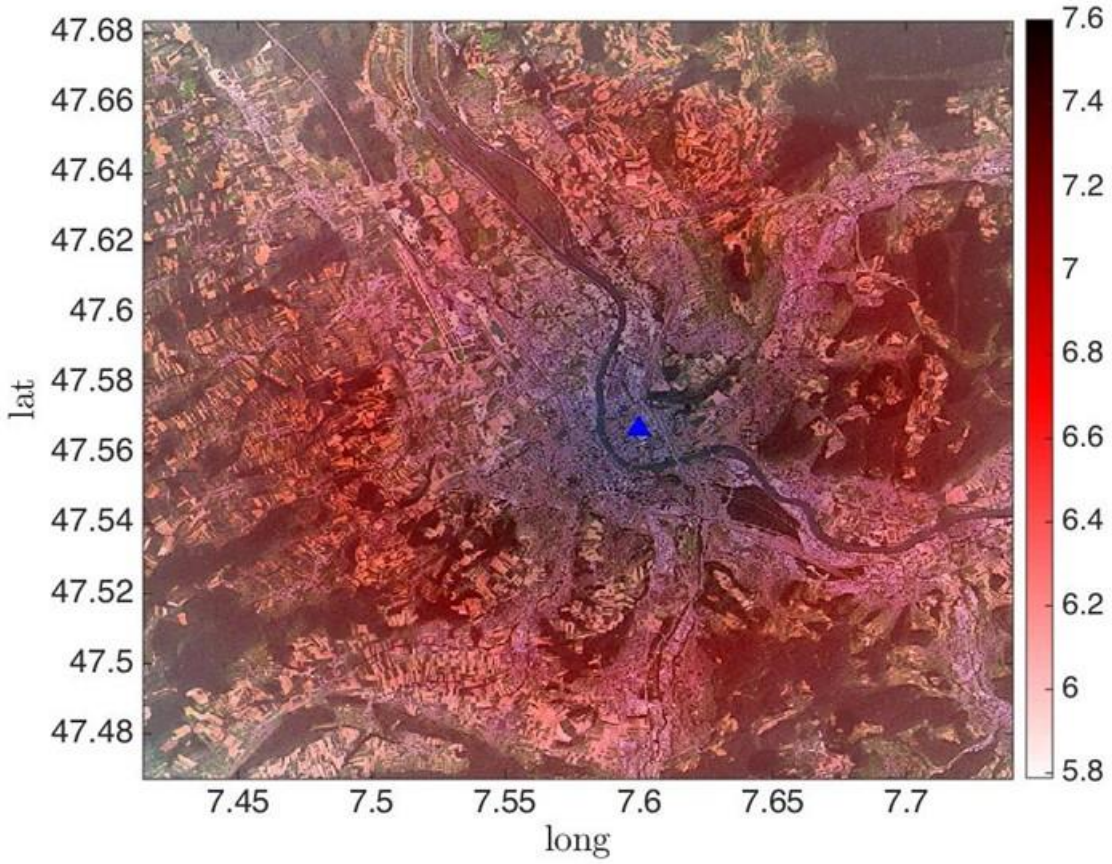
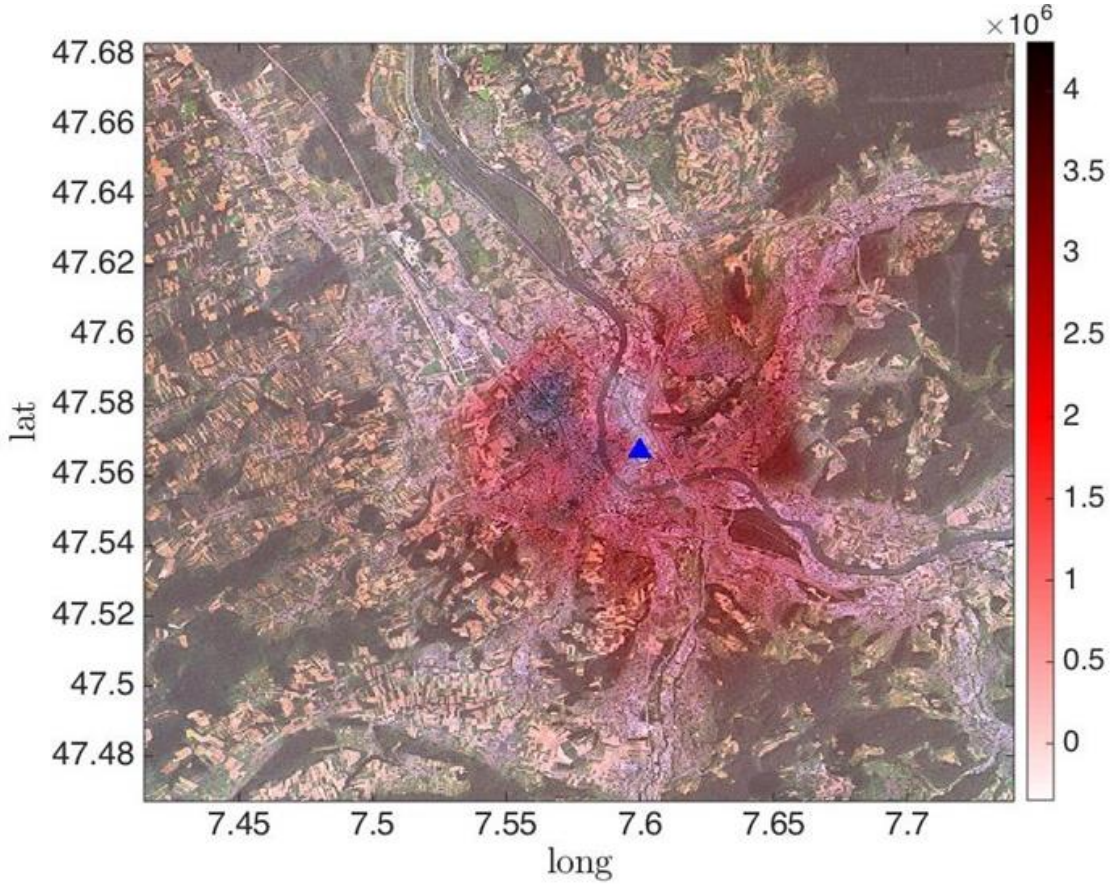


hazard map



risk map

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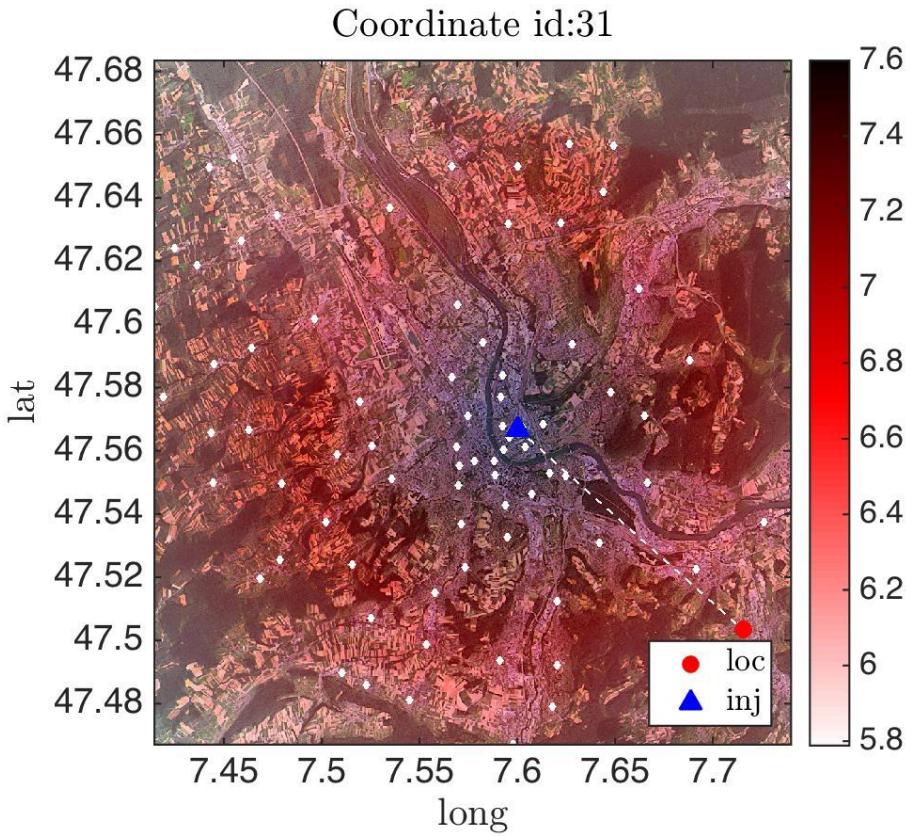

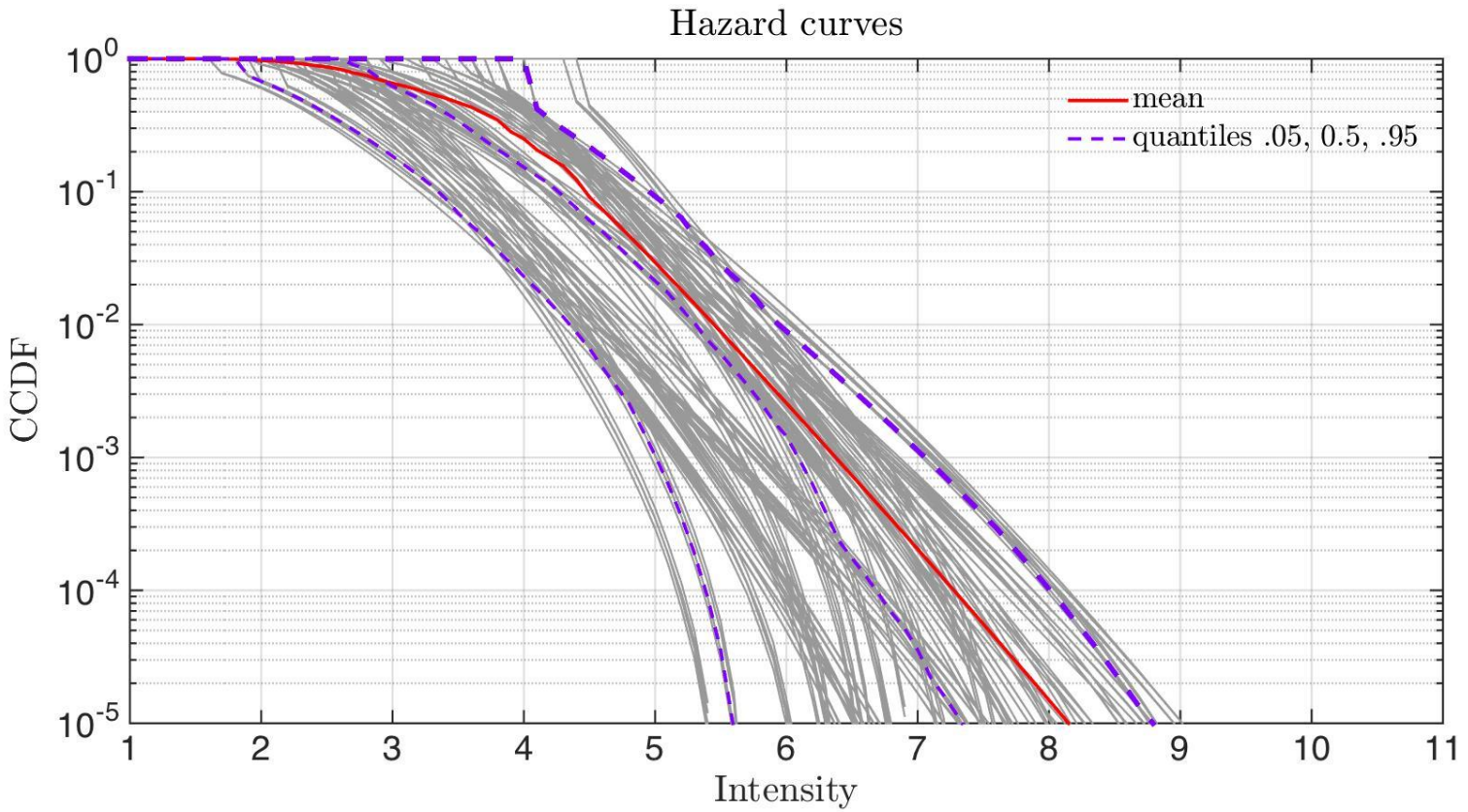

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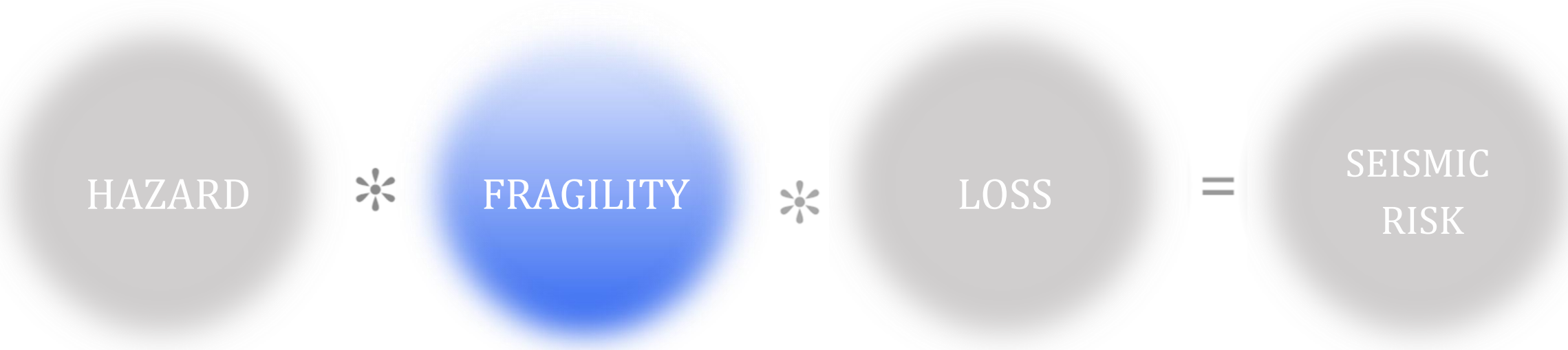

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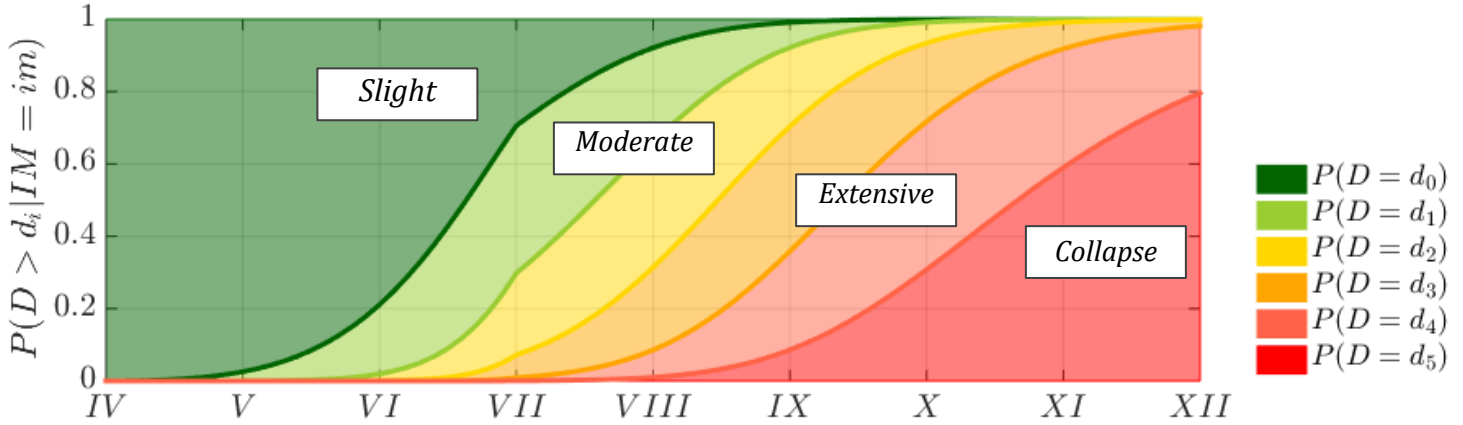
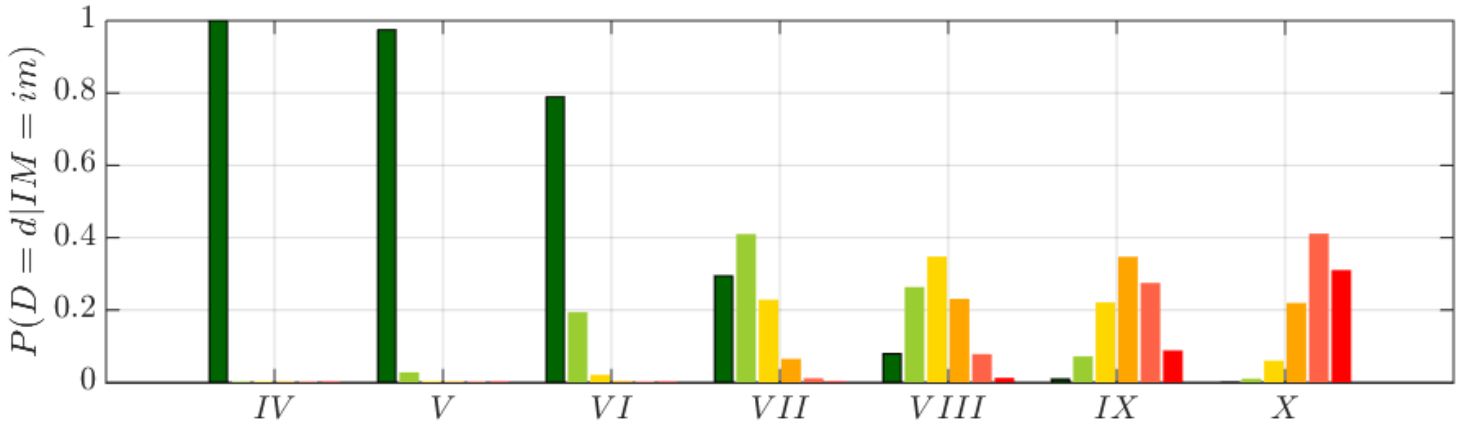
DG 1:
Slight Damage

DG 2:
Moderate Damage

DG 3:
Extensive Damage

DG 4:
Complete Damage





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PBEE-PEER framework

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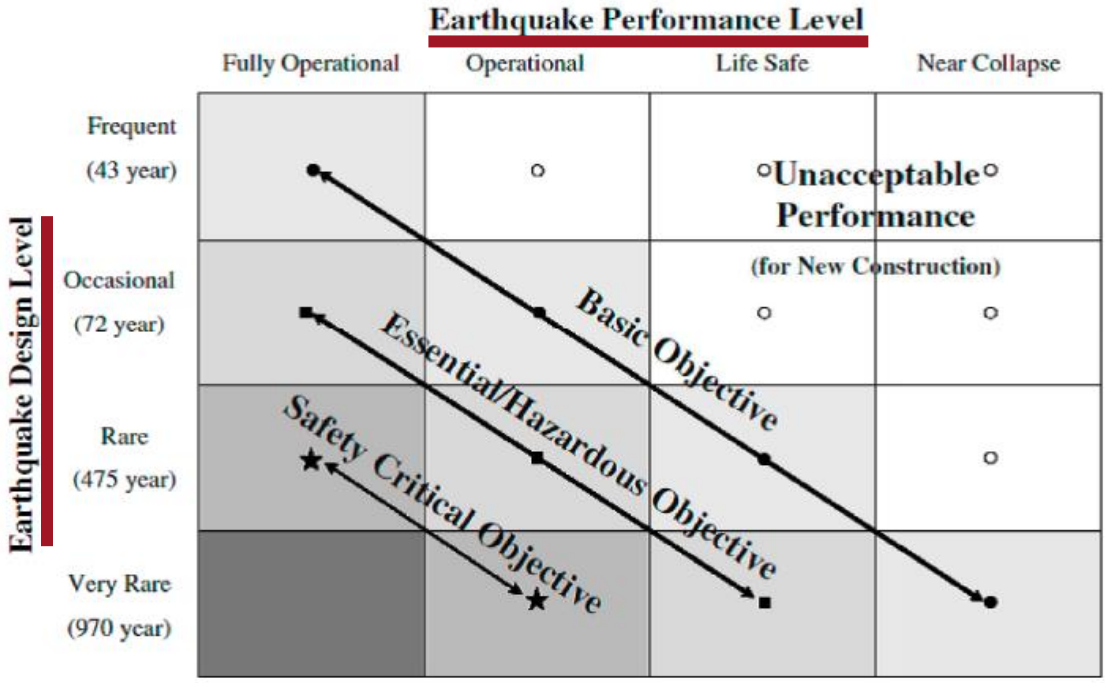
PBEE: **P**erformance **B**ased **E**arthquake **E**ngineering



PBEE concept: seismic performance objectives *vs* seismic hazard level. ©*Poland et al.,(1995)-Vision 2000: Performance Based Earthquake Engineering of buildings. Structural Engineers Association of California, Sacramento, CA.*

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The **PEER-PBEE** Framework

$$IM \longrightarrow EDP \longrightarrow DM \longrightarrow DV$$

$$\lambda(dv) = \int_{d} \int_{edp} \int_{im} G(dv|d)|dG(d|edp)||dG(edp|im)||d\lambda(im)|$$

where im is an intensity measure (e.g., peak ground acceleration, peak ground velocity, spectral acceleration, etc.), edp is an engineering demand parameter (e.g., interstorey drift), d is a damage measure (e.g., minor, medium, extensive, collapse), dv is a decision variable (e.g., monetary losses, fatalities, etc.), $\lambda(x)$ is the mean annual rate of events exceeding a given threshold for a given variable x, and $G(y|x) = P(Y \geq y|X = x)$ is the conditional complementary cumulative distribution function (CCDF)

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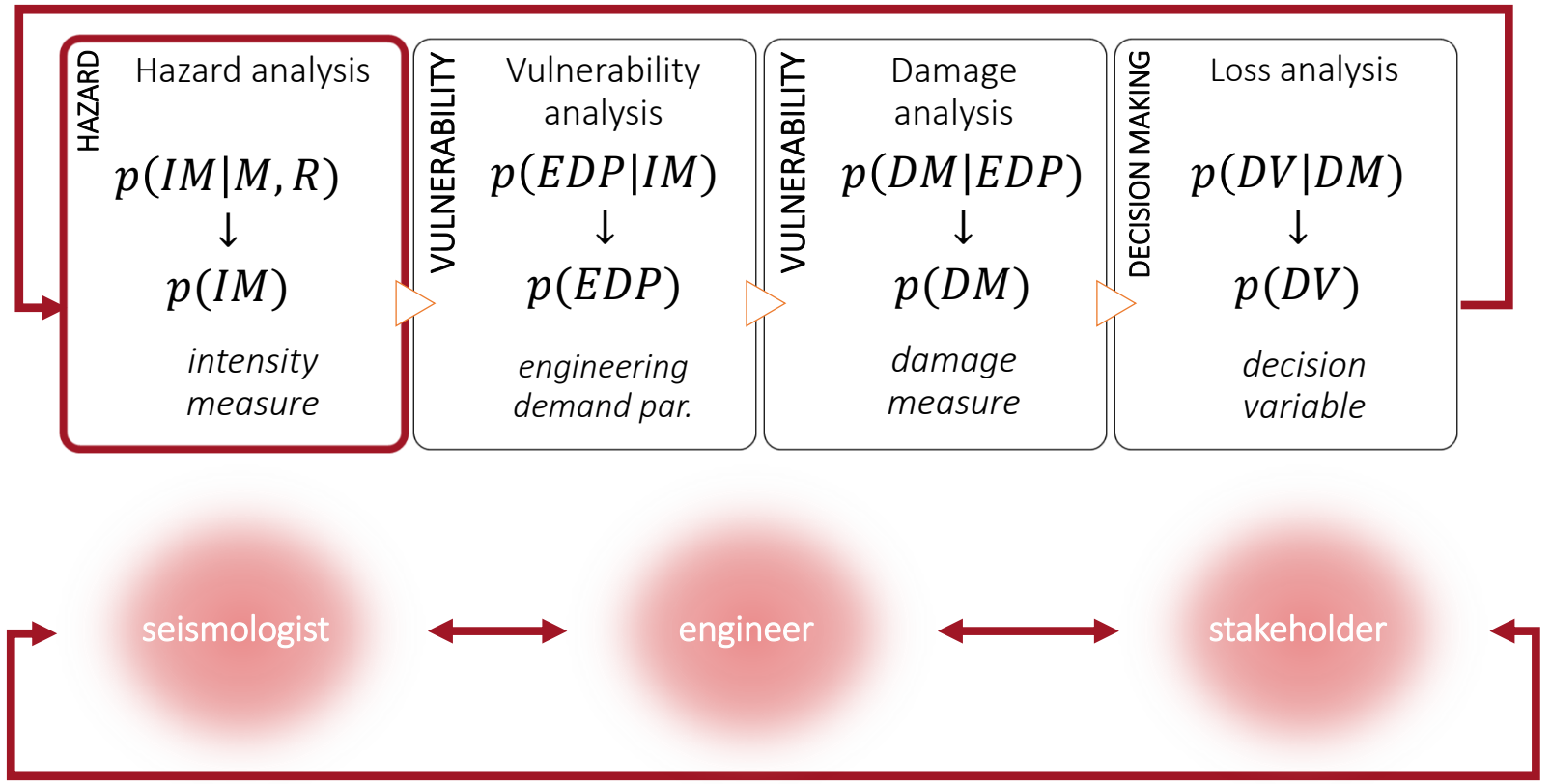
The **PEER-PBEE** Framework



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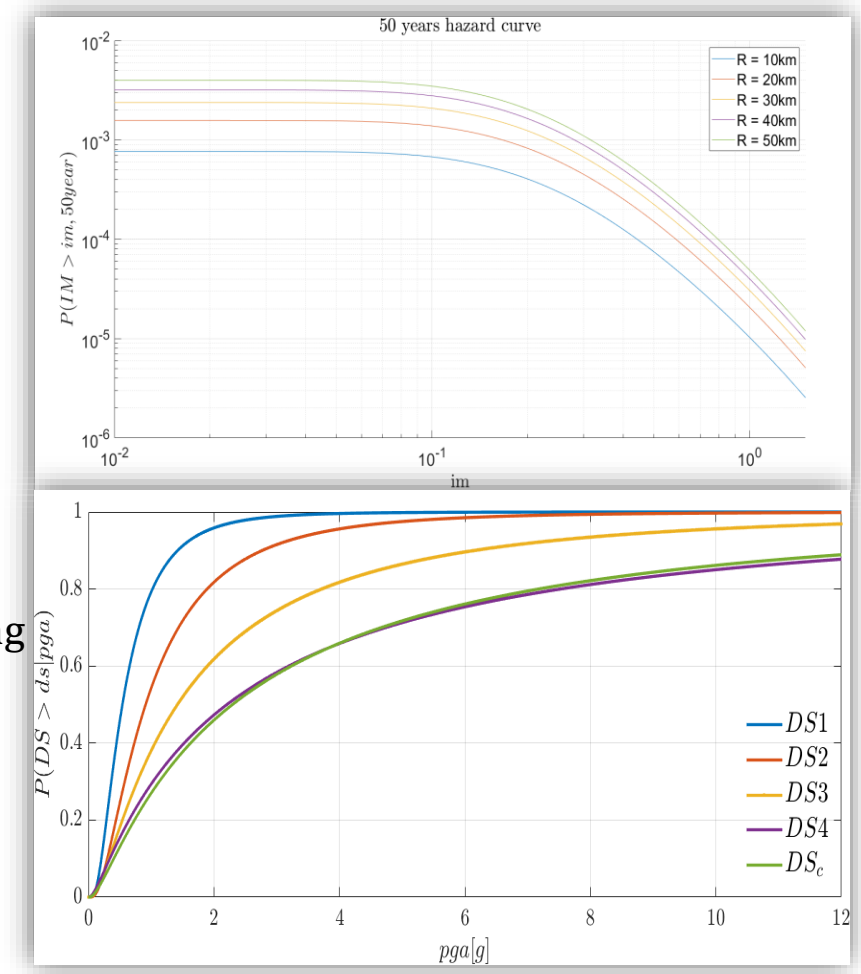
Objectives & Lecture Plan:

- (1h00) Probabilistic seismic hazard (C.Nardin)
  - i. Definition and time scales
  - ii. Models of earthquake occurrence and hazard integral
  - iii. LAB → PSHA
- (0h45) Vulnerability (C.Nardin)
  - i. Fragility functions: methods and applications
  - ii. LAB → Computation of probability of damage state of a building



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