Engineering Seismology and Seismic Hazard – 2019

Lecture 1

Course Introduction

Valerio Poggi
Seismological Research Center (CRS)
National Institute of Oceanography and Applied Geophysics (OGS)

Get to know each other

Lecturer:

Valerio Poggi
National Institute of Oceanography and Applied Geophysics

Teaching Assistants:

Kendra Johnson
Robin Gee
Global Earthquake Model Foundation (GEM)

Onur Deniz Akan
IUSS – Istituto Universitario di Studi Superiori di Pavia

Students:

Give a short description of you (name, home place, interests….)

Get to know: the Lecturer

Valerio Poggi

Bsc+Msc Geology

UNIVERSITÀ DEGLI STUDI DI MILANO

PhD Geophysics

ETH

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Researcher/Lecturer

Schweizerischer Erdbebendienst
Service Sismologique Suisse
Servizio Sismico Svizzero
Swiss Seismological Service

Hazard Scientist

GEM
GLOBAL EARTHQUAKE MODEL
working together to assess risk

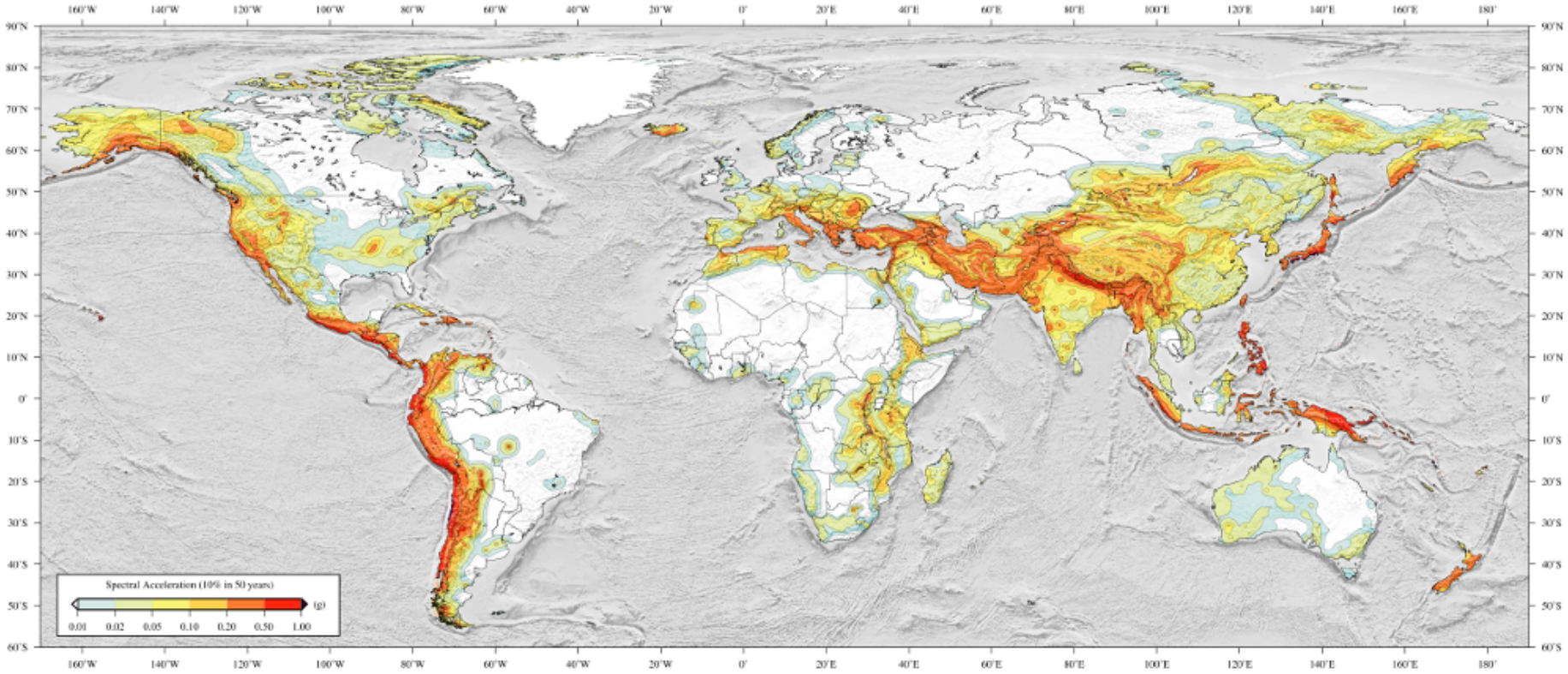
Researcher

OGS

Get to know: the Lecturer

OPENQUAKE
calculate share explore

GEM Global Mosaic of Seismic Hazard Models



Get to know: the T.A.

Kendra

Robin

Get to know: the Students

Your turn, please...

Goals

The course aims at providing the students with the essential knowledge and skills to face most common seismology problems in engineering and applied geophysical practice.

The course splits into two main blocks:

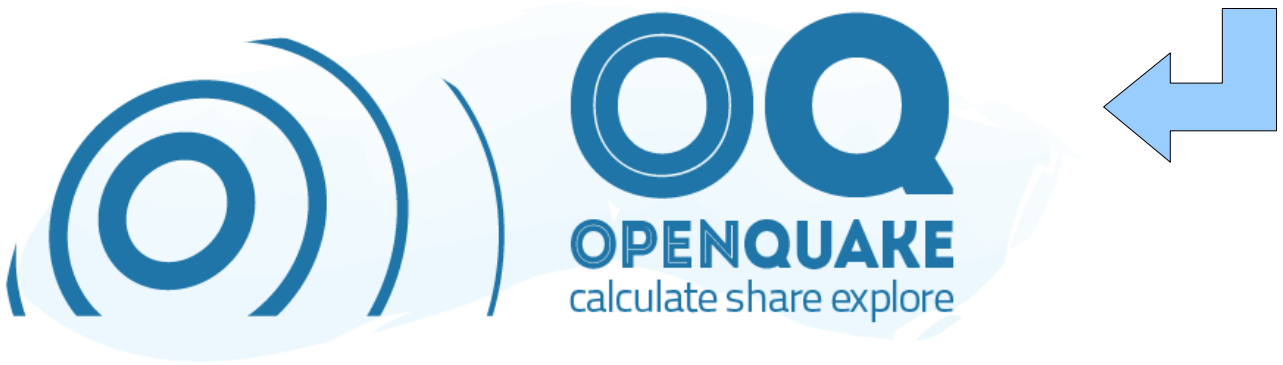
A) in the first module, hints of theoretical seismology are provided, with a special focus on elastic wave propagation, e.g. body and surface wave solution, source representation, attenuation;

B) in the second module, more specialised topics of engineering interest are discussed, such as intensity measures, ground motion prediction equations, seismic hazard assessment (deterministic and probabilistic) and microzonation analysis.

What will you gain

After completion of the course, the student should:

1) gain an understanding of the basics of seismology
2) understand the complex mechanisms that govern the occurrence of earthquakes, and the generation of damaging ground motions.
3) be familiar with the wide possibilities of building a seismic hazard model, and understand the seismic hazard (deterministic and probabilistic)
4) have the necessary knowledge to use (and understand) the most common seismic hazard software tools, e.g. OpenQuake



Syllabus: first week

Week	Day	Date	Lecture	Content
1	1	Mon. 1.4.2019 (9.00-12.00)	Introduction	Goals of the course and schedule; Introduction to earthquakes; Brief history of seismology; Seismic hazard and risk
			Seismotectonics	Global seismicity distribution ; Structure of the earth; Plate tectonics; Type of plate boundaries; Seismogenic faults and their representation; Stress accumulation and elastic rebound theory
	2	Tue. 2.4.2019 (9.00-12.00)	Elastostatic	Review on vector calculus; Deformation, stress and strain; Generalized Hooke law; Elastic moduli
			Elastodynamic	Differential wave equations; Helmoltz potentials; P and S wave solutions
	3	Wed. 3.4.2019 (9.00-12.00)	Wave and media	Ray parameter, slowness; P, SH, SV polarisation; Reflection and transmission coefficients; Snell's law; Critical angle
	4	Thu. 4.4.2019 (9.00-12.00)	Surface waves	Evanescent waves; Eigenvalue problem for Rayleigh and Love; waves; Velocity dispersion and polarization
			Attenuation	Intrinsic attenuation; Wave solution using complex velocities; Geometrical spreading; Scattering
	5	Fri. 5.4.2019 (9.00-12.00)	The seismic source	Point source and Green tensor; Extended source: double couple solution; Moment tensor; Radiation pattern; Focal mechanism. Beach-ball representation; The far-field Brune's spectral model
			Earthquake location	Introduction to inverse problems in geophysics; Epicentral and hypocentral location solution; P-S travel-time delay; Triangulation

Syllabus: second week

Week	Day	Date	Lecture	Content
2	1	Mon. 8.4.2019 (9.00-12.00)	Exercises with T.A. Revision / Questions	
	2	Tue. 9.4.2019 (9.00-12.00)	Size of earthquakes	Macroseismic intensity scales; Peak ground estimates: PGD, PGV, PGA; Response and pseudo-response spectrum; Magnitude scales: Ml, Ms, mb, Md; Earthquake energy, scalar moment and moment magnitude Mw
	3	Wed. 10.4.2019 (9.00-12.00)	Seismic occurrence analysis	Earthquakes catalogues; Poisson assumption. Magnitude of completeness; Magnitude frequency distributions; The characteristic earthquake model; Occurrence from geology and geodesy; Aftershocks, Omori's law; Catalogue declustering; Short-term forecasting: precursors and seismic gap theory
	4	Thu. 11.4.2019 (9.00-12.00)	Ground motion prediction equations	Source, path and site term; Regional and global strong motion datasets; Empirical and physics based models; Data fitting; Uncertainty and sigma
	5	Fri. 12.4.2019 (9.00-12.00)	Deterministic seismic hazard assessment	The worst case scenario; Numerical and empirical modelling approaches
			Probabilistic seismic hazard assessment	Probabilistic vs. deterministic approach; Source models: distributed seismicity and finite fault models; Scaling relations; Maximum magnitude; Review of probability; Hazard integral; Probability of exceedance; hazard curves; Uniform hazard spectra; Logic trees and epistemic uncertainty; Seismic hazard disaggregation

Syllabus: third week

Week	Day	Date	Lecture	Content
3	1	Mon. 15.4.2019 (9.00-12.00)	Exercises with T.A. Revision / Questions	
	2	Tue. 16.4.2019 (9.00-12.00)	Site effects and microzonation	Seismic impedance amplification; Seismic resonance; The analytical soil transfer function; Topographic and 2D/3D geometric effects; Non-linear soil behaviour, liquefaction and cyclic mobility; Examples of microzonation studies; Soil classification, proxies; National regulations and building codes
	3	Wed. 17.4.2019 (9.00-12.00)	Seismometry	Seismometers and instrument response; Seismic networks; Early warning systems
			Principle of digital signal processing	Time series analysis; Digital representation: quantization and sampling; Fourier analysis; Correlation, convolution, filtering
	4	Thu. 18.4.2019 (9.00-12.00)	Exercises with T.A. Revision / Questions	

Syllabus: fourth week

Week	Day	Date	Lecture	Content
4	1	Mon. 29.4.2019 (9.00-12.00)	Seismic exploration and site characterisation	Reflection and refraction seismic; Tomography; Surface wave analysis; Ambient vibration techniques
	2	Tue. 29.4.2019 (9.00-12.00)	Invited Seminars Open discussion	
	3	Thu. 2.5.2019 (9.00-12.00)	Personal project presentation	
	4	Fri. 3.5.2019 (9.00-12.00)	Exam	

Qualification & Grading

The course is concluded by both a **personal project** and a **written exam.**

The personal project consists in the elaboration of a seismic hazard model from literature using the OpenQuake software. The student is expected to present his elaboration to the class and to the examiner by means of a brief slide show (20min. plus some time for questions).

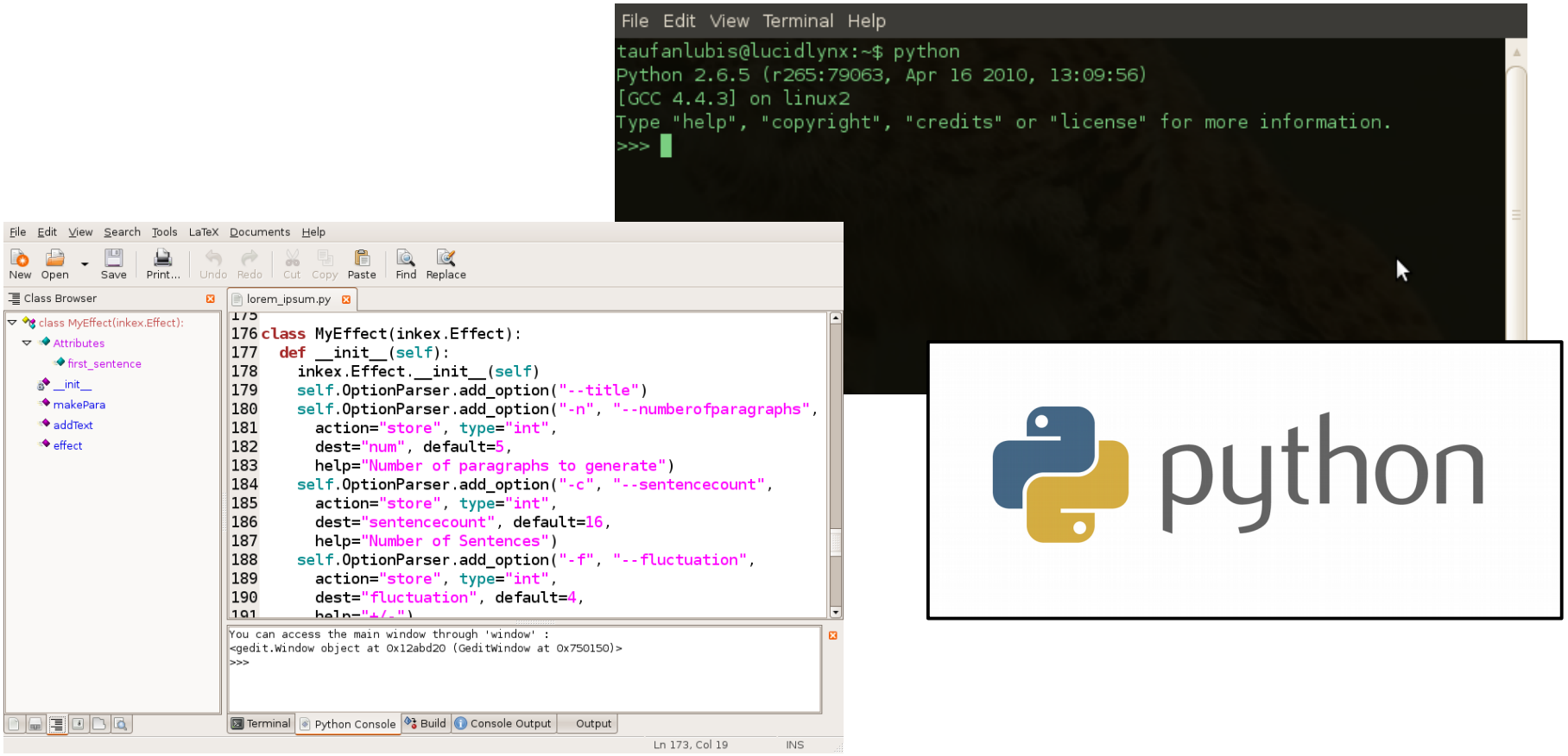
The written exam consists of a multiple-choice test and the solution of an exercise.

ACTIVITIES	PERCENTAGE
Class participation	10%
Project presentation	30%
Final Exam	60%

Prerequisites

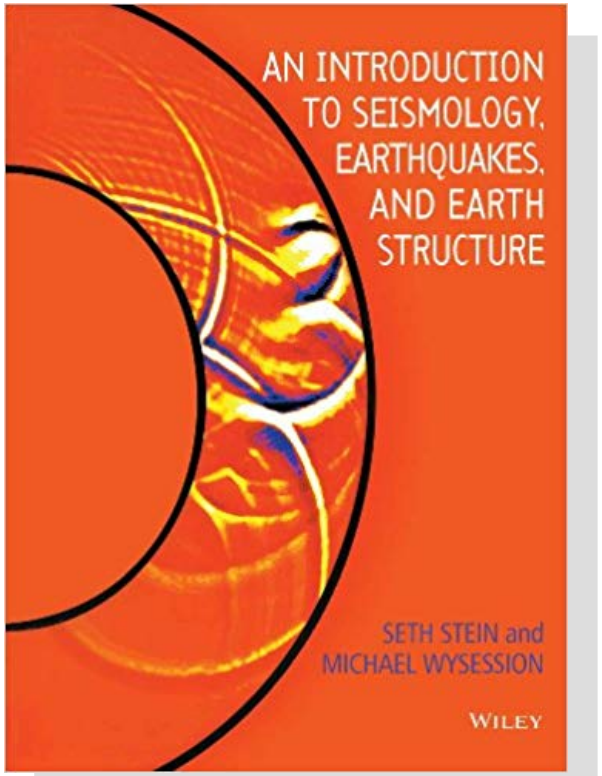
Advanced calculus and linear algebra are useful, although not a requirement for the course.

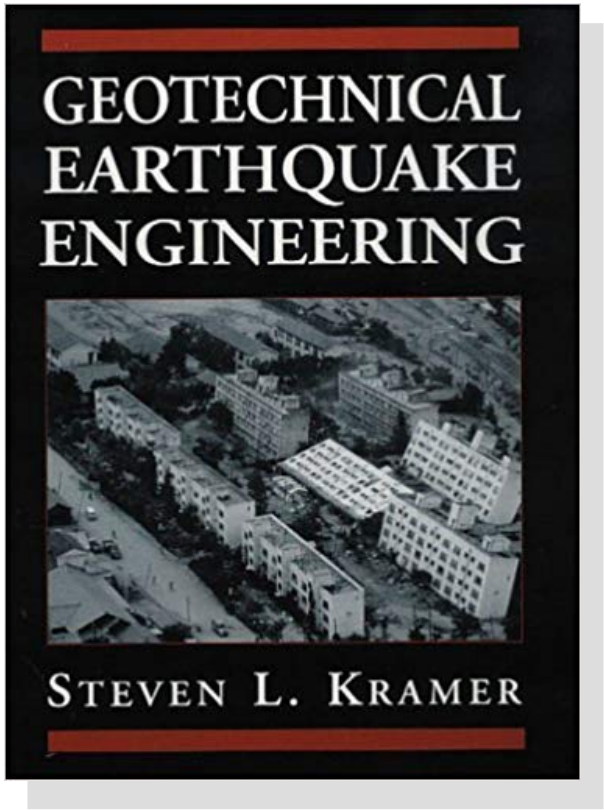
The course lab will make use of Python language for some exercises, therefore some familiarity with computer programming is recommended.



Reference Textbooks

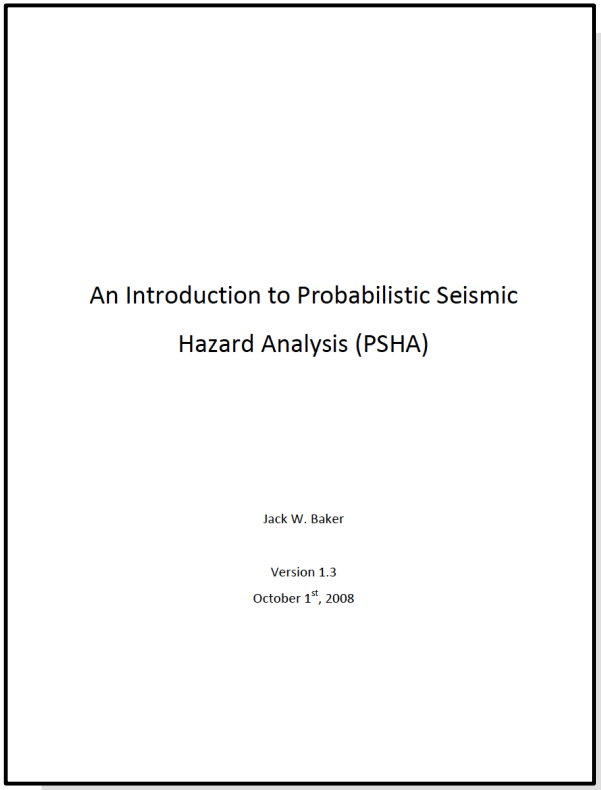
- Stein S., and M. Wysession. An Introduction to Seismology, Earthquakes, and Earth Structure. 1st ed. Malden, MA: Blackwell, September 2002. ISBN 9780865420786.
- Kramer, S.L., Geotechnical Earthquake Engineering, Prentice Hall, 1996, ISBN 0133749436





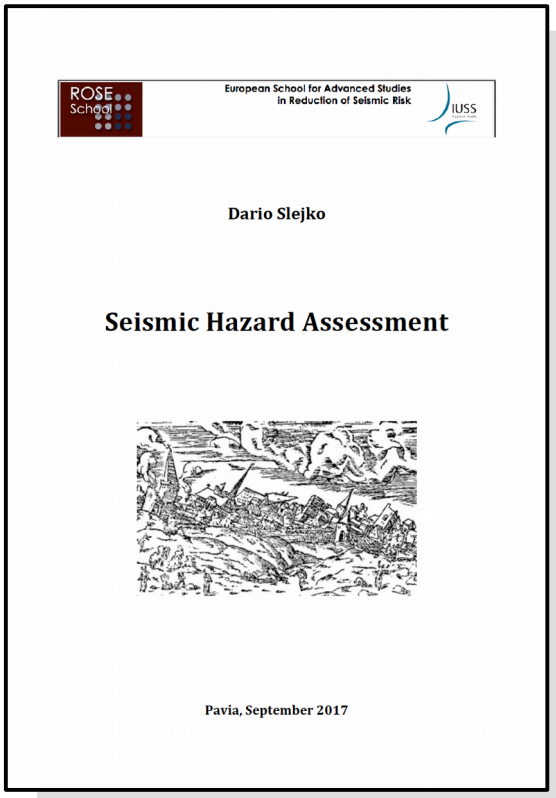
Additional Resources

- Lecture slides
- Course notes from Dr. Dario Slejko (OGS Trieste)
- Additional material (articles, tutorials) provided during the course
- YOUR NOTES


An Introduction to Probabilistic Seismic Hazard Analysis (PSHA)

Jack W. Baker

Version 1.3
October 1st, 2008


ROSE School

European School for Advanced Studies in Reduction of Seismic Risk

IUSS

Dario Slejko

Seismic Hazard Assessment

Pavia, September 2017

Course Material

You will find the course material (lecture slides) and additional resources (tutorials, exercises, etc.) at the following link:

http://seismo.org/Share/ES2019

Username: seismo Password: seismo

For anything you might need, just ask me or the teaching assistants!