Schweizerischer Erdbebendienst
Service Sismologique Suisse
Servizio Sismico Svizzero
Servizi da Terratrembels Svizzer

Workshop
Building resilient communities through urban planning and the integration of the Natural Sciences
13 January 2015

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Earthquake Hazard and Risk in Urban Areas

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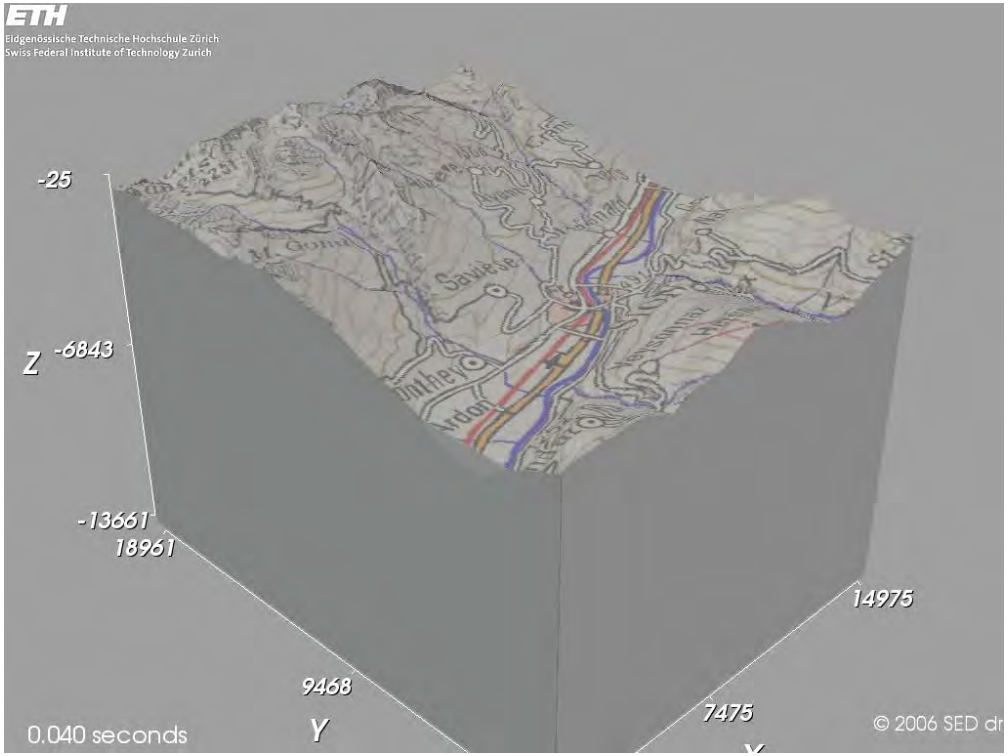
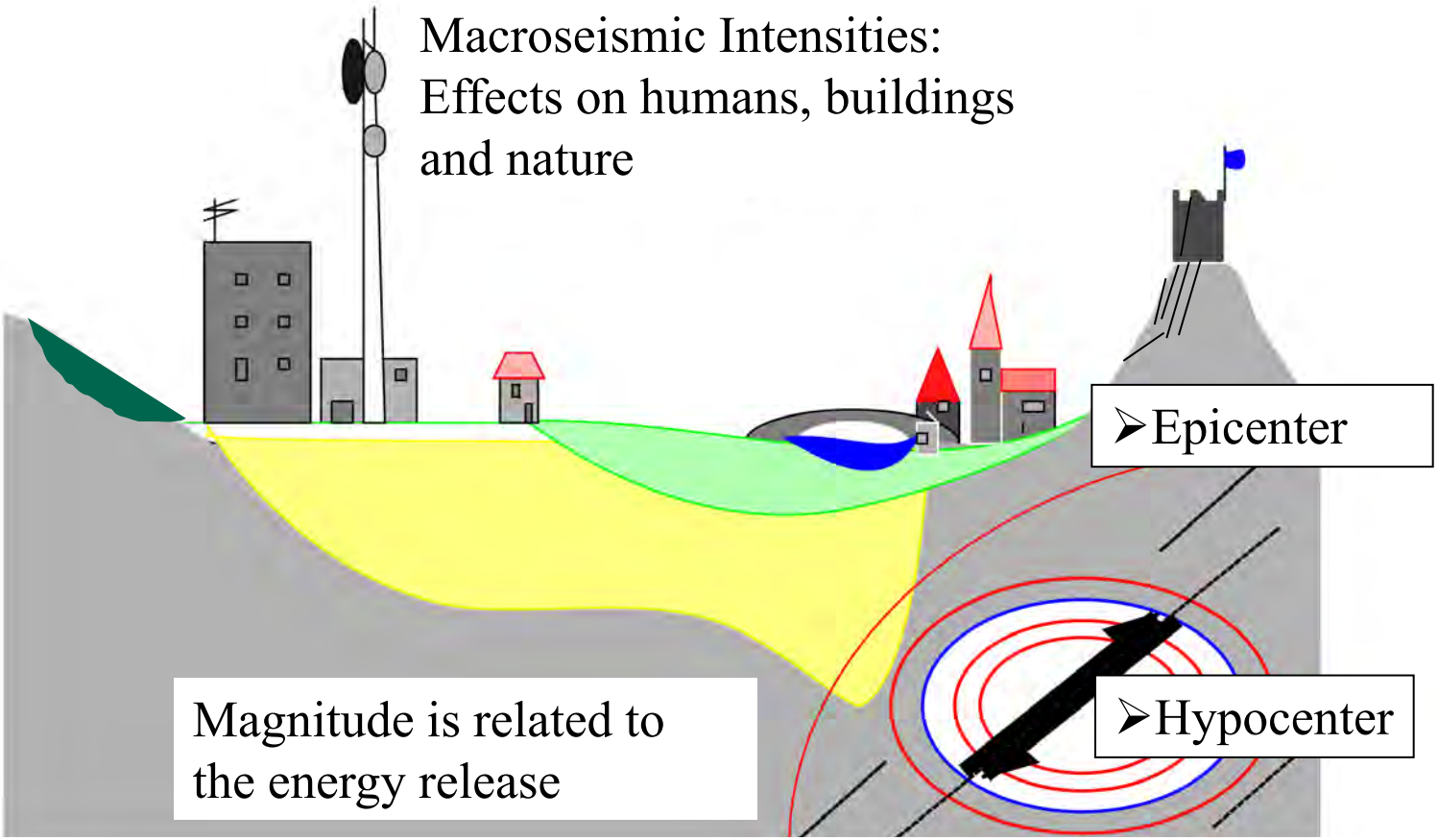


Numerical simulation
Earthquake at Sion/Sierre
January 25, 1946

Issues

- Earthquake ground motion (magnitude, distance, soil conditions, ..)
- Earthquake-induced effects (tsunamis, landslides, liquefaction, fire, ..)
- Vulnerability of structures (building codes, technological risks, ..)



11.3.2011, M9.0 Tohoku, Japan

«Unexpected» earthquake >> Tsunami >> Nuclear accident

Problems and challenges:

- Science and knowledge
- Communication and implementation
- Society and economic interests

12.1.2010, M7.0 Haiti

Earthquake in urban area >> Vulnerable society >> High impact

Problems and challenges:

- «Moderate» seismicity and blind faults
- Science (250 yrs. earthquake cycle)
- Poverty and vulnerability
- Preparedness

Challenges of the modern society:

Earthquake (natural) hazards tend to become more and more important

- Mass media inform/ the public is sensitized

- Vulnerability and extent of earthquakes losses are increasing:

  a) Increase of the Earth's population especially in large cities

  b) Settlement in areas that have been avoided in earlier times

  c) Risks grow faster than the economic growth

  d) Disasters hit the most vulnerable

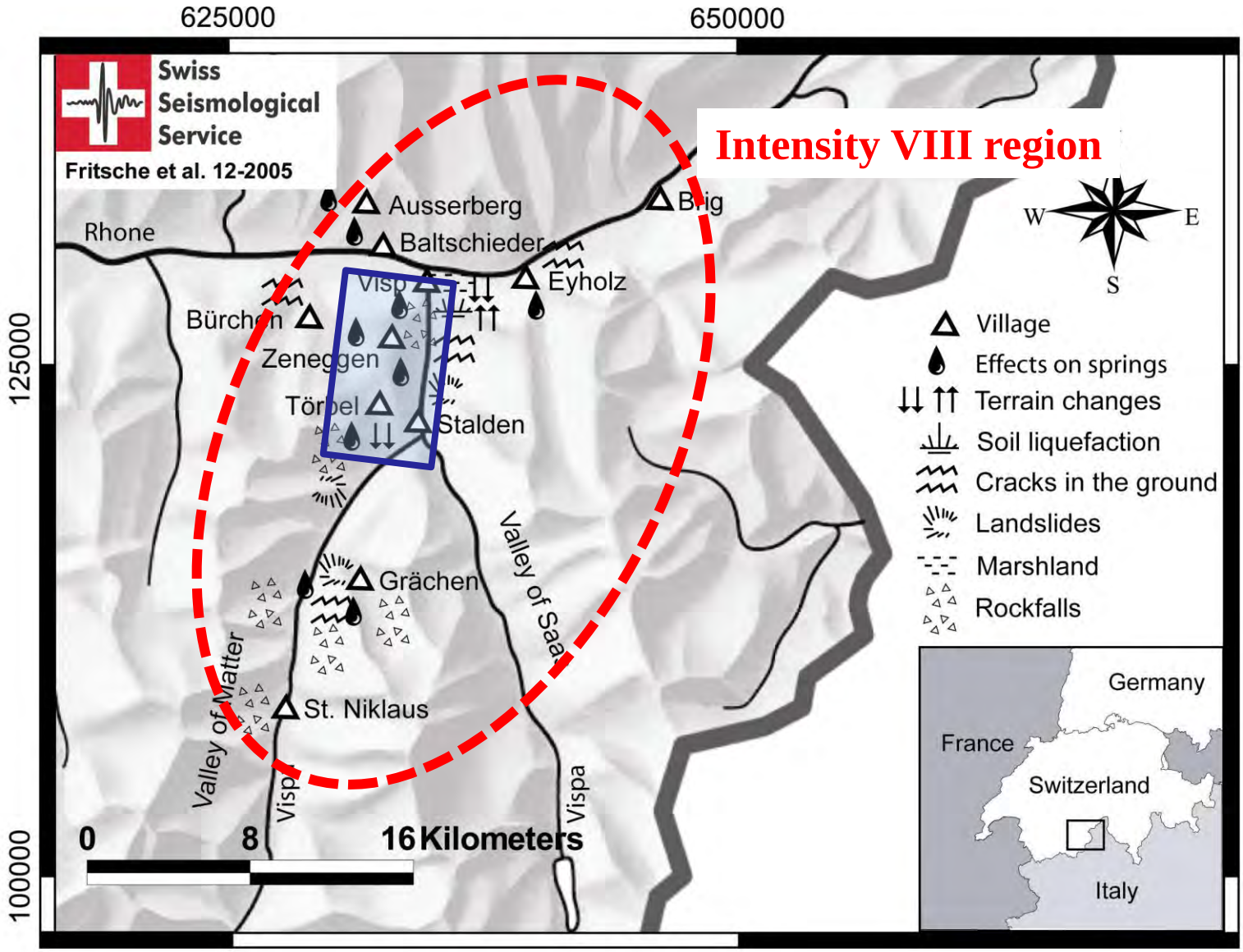
  e) Use of technologies with particularly high risk

- Strong earthquakes are rare - but the impact can be very high

- There will be unexpected earthquakes in the next decades
  but no tools to predict them!

What happened during past earthquakes?

Direct and induced phenomena (Visp 1855, Mw=6.2)



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What would happen today?
Global increase of risk with time!

Urban development at Visp (Valais)

1850

1940

1980

River Regulation

Today

Requirements for decision making in urban planning:

1) Nature, frequency and size of the events as well as the possible impacts have to be studied (Probabilistic methods).

2) Today modeling tools are applied to predict impacts:
There is a need to control the quality & uncertainties of input data and of the modeling itself.

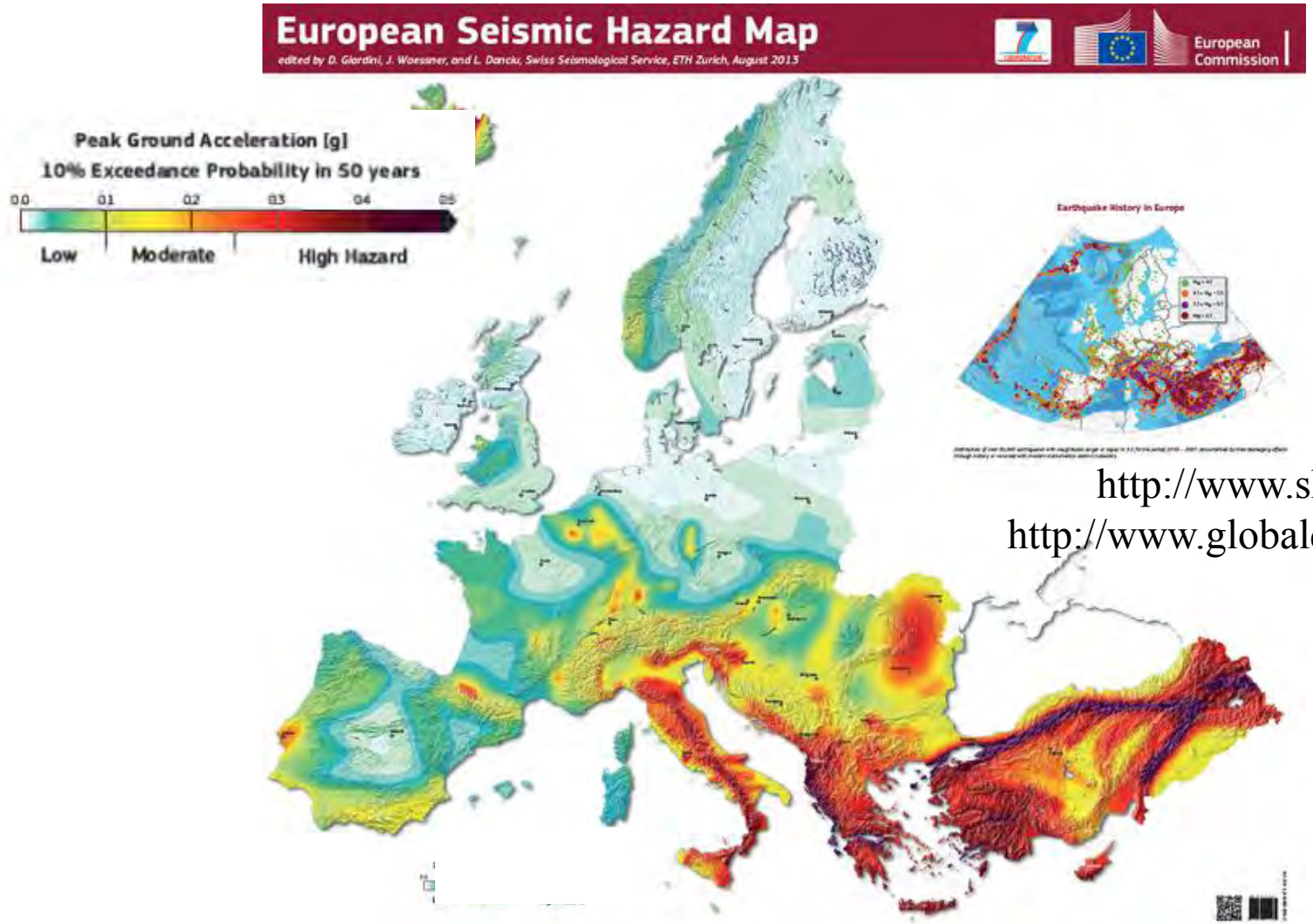
4) Also the "worst" cases have to be considered (Deterministic methods).

5) The knowledge has to be translated into:

a) Land-use planning (with an optimum cost/benefit ratio)
b) Risk-based decision making
b) Tools for education (Awareness is the most effective measure)
c) Tools for early warning in particular cases

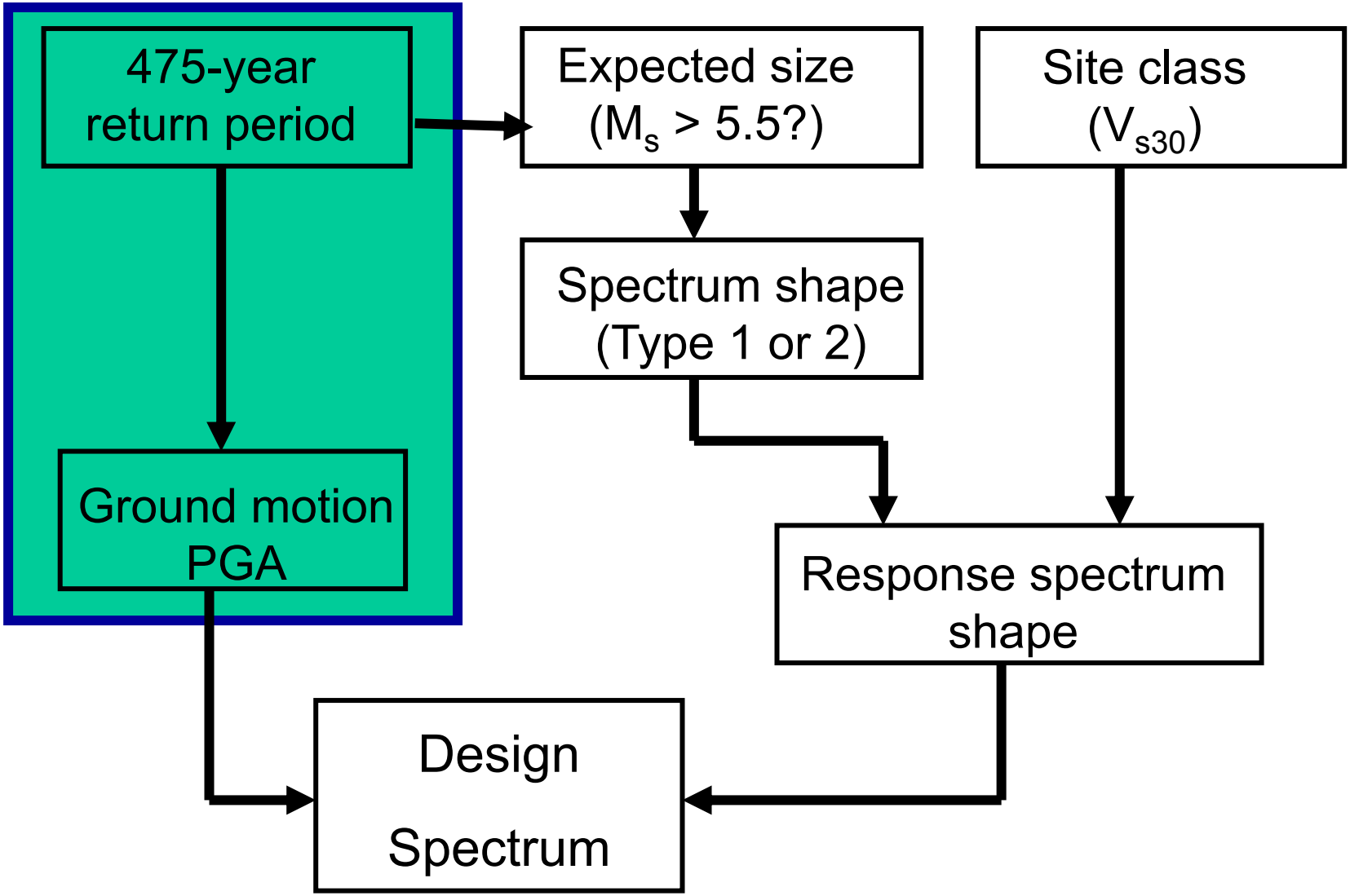
Mapping earthquake Hazard

Probabilistic / for rock sites / global - regional - national

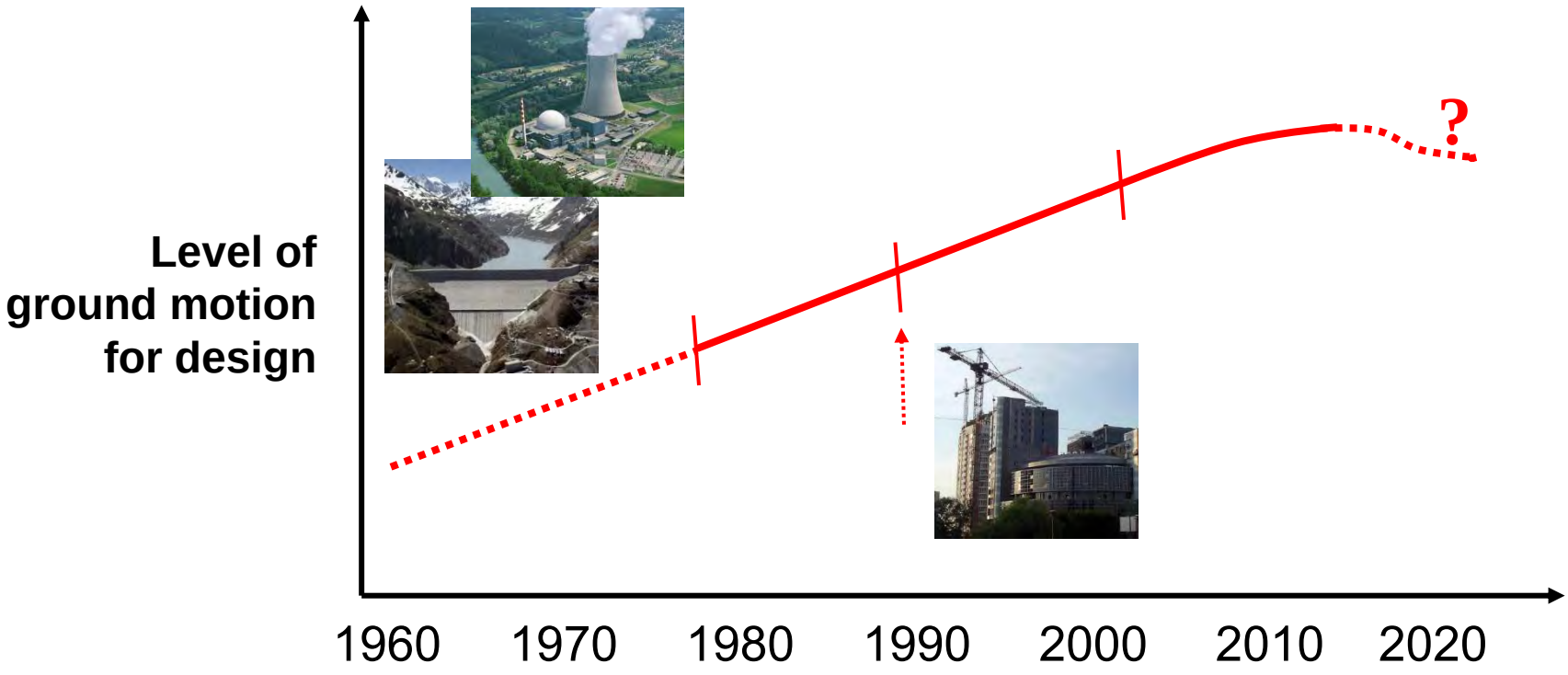


http://www.share-eu.org
http://www.globalquakemodel.org/

Building codes: Basic inputs and decisions for normal buildings



Design values increased in time



1960- 1980: from „incomplete“ deterministic to probabilistic methods

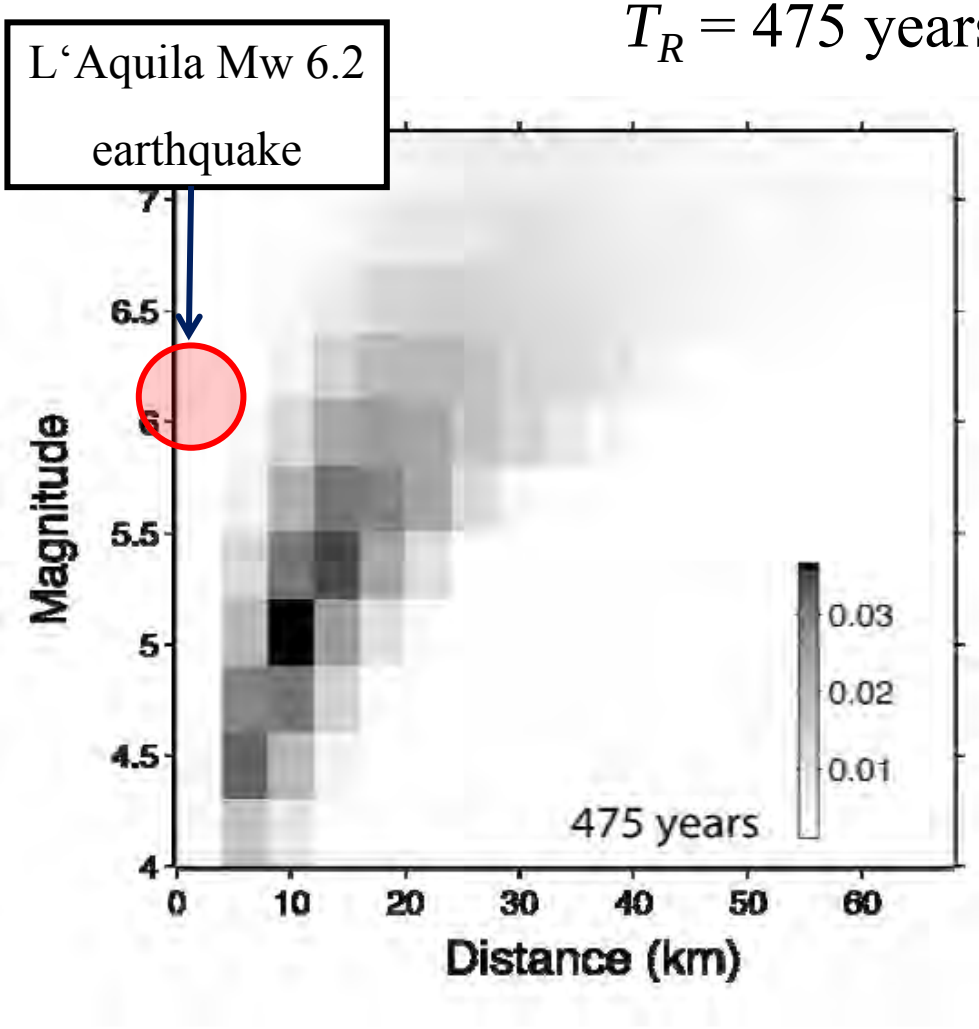
1980- : Probabilistic methods include uncertainties

We always learn from new earthquakes

(Recordings in the near field, maximum ground motion)

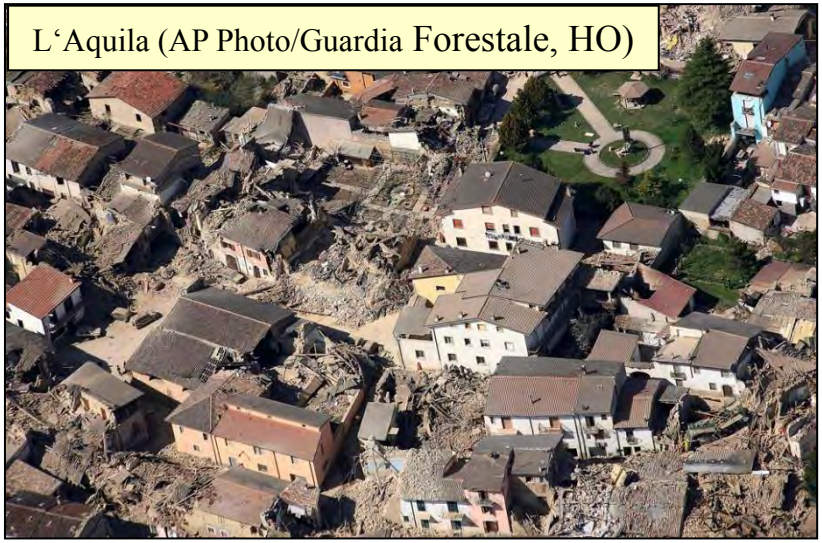
Accepted risk

Deaggregation (Earthquakes covered by the building codes)
T_R = 475 years, CH-Z3b



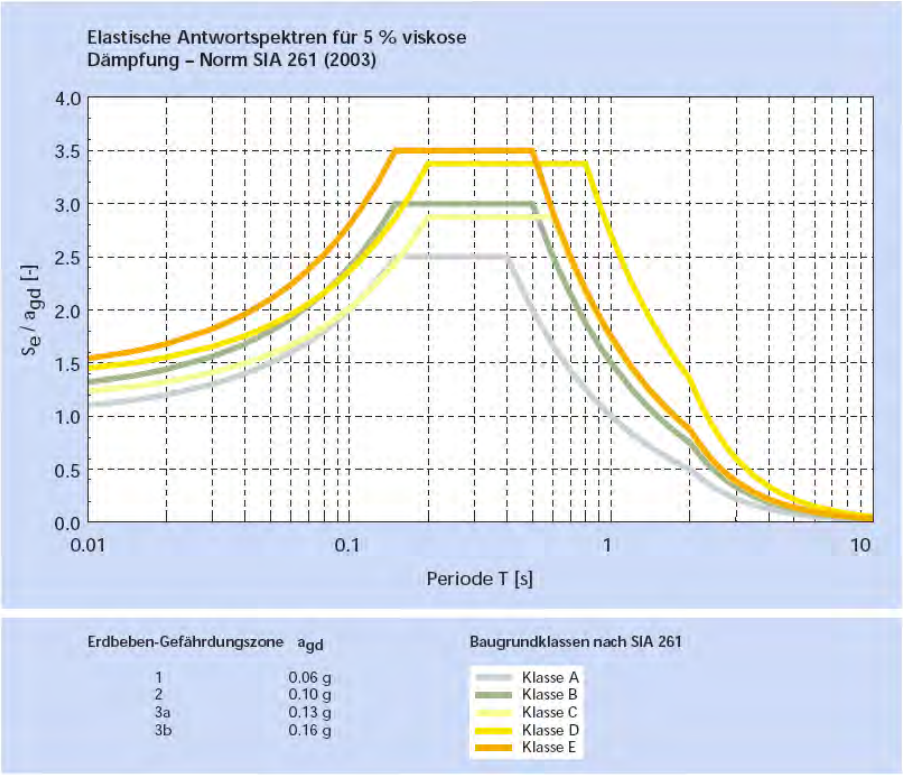
In the near-field:

Design spectra can be exceeded for events that occur in the seismotectonic region also with less than 475 years return period

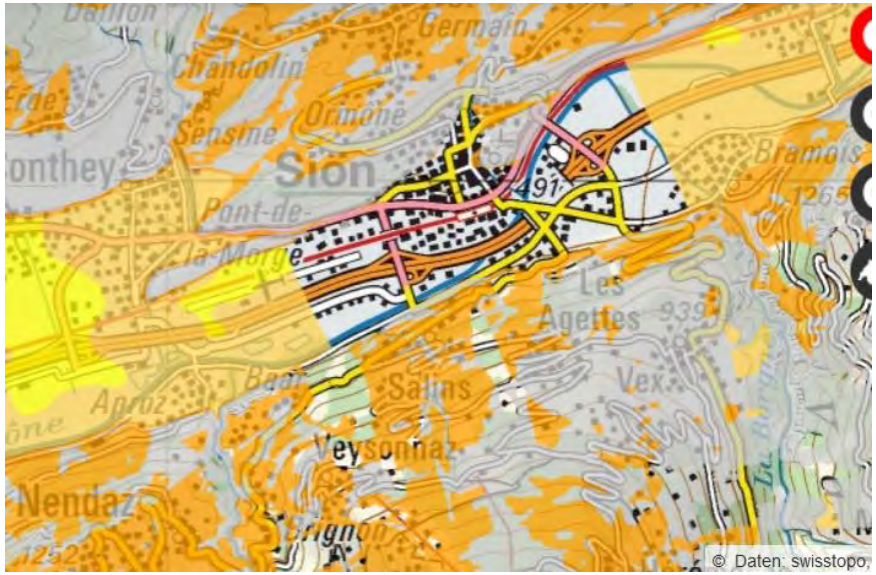

L'Aquila (AP Photo/Guardia Forestale, HO)

Site-effects in building codes (EC8)

Different elastic design spectrum for different soil classes



Swiss Building Code SIA261



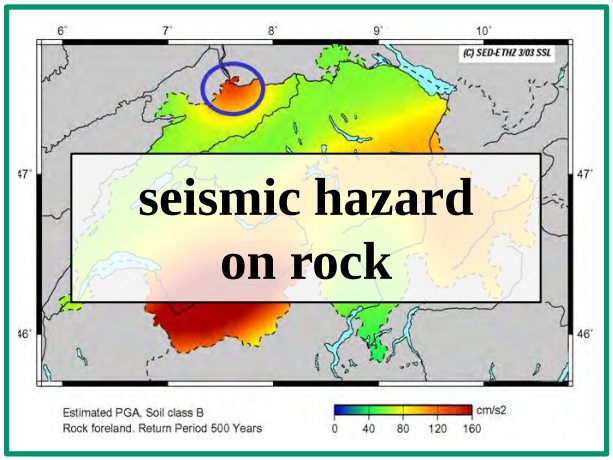
Soil class maps to support the application of the code (http://erdbeben.admin.ch)

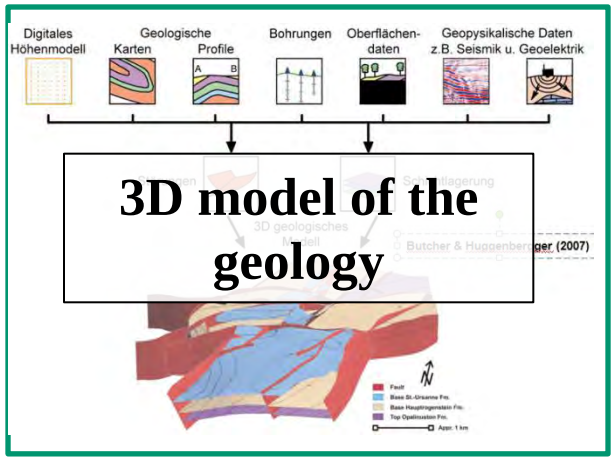
- One soil class covers a large variety of conditions, but no special cases
- The design spectra should generally be conservative at long periods
- Soils with non-linear behaviour (e.g. liquefaction) are not covered

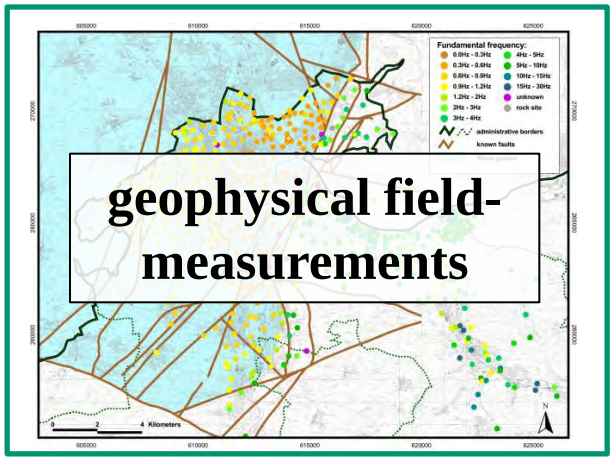
How to make the assessment more site-specific?

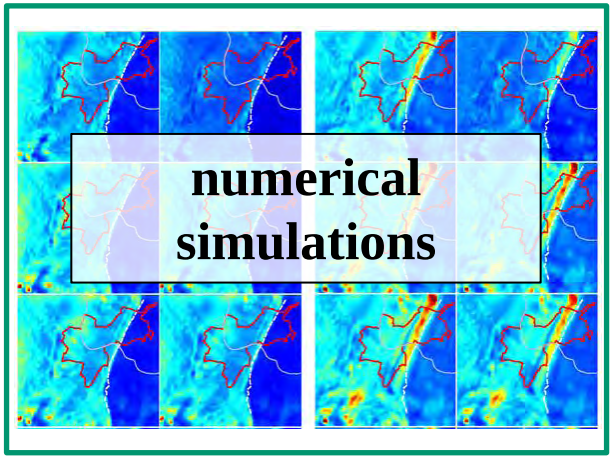
Example: microzonation for wider Basel region (2003-2009):

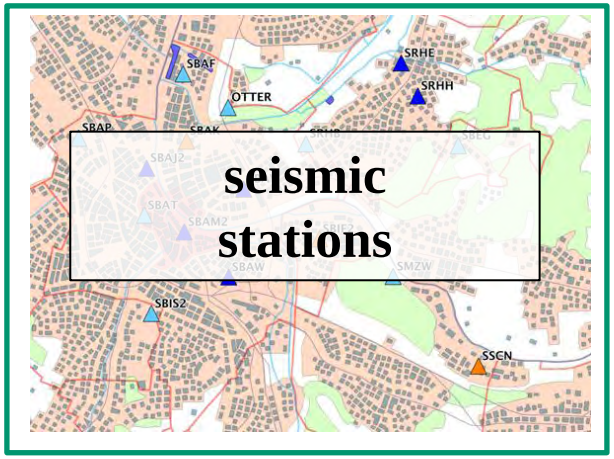
- Design spectra based on ….

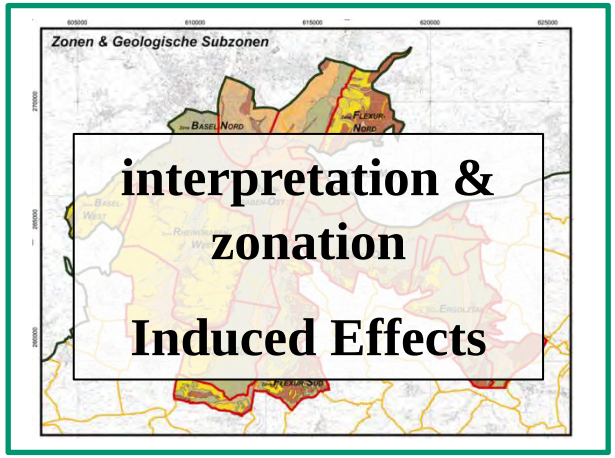








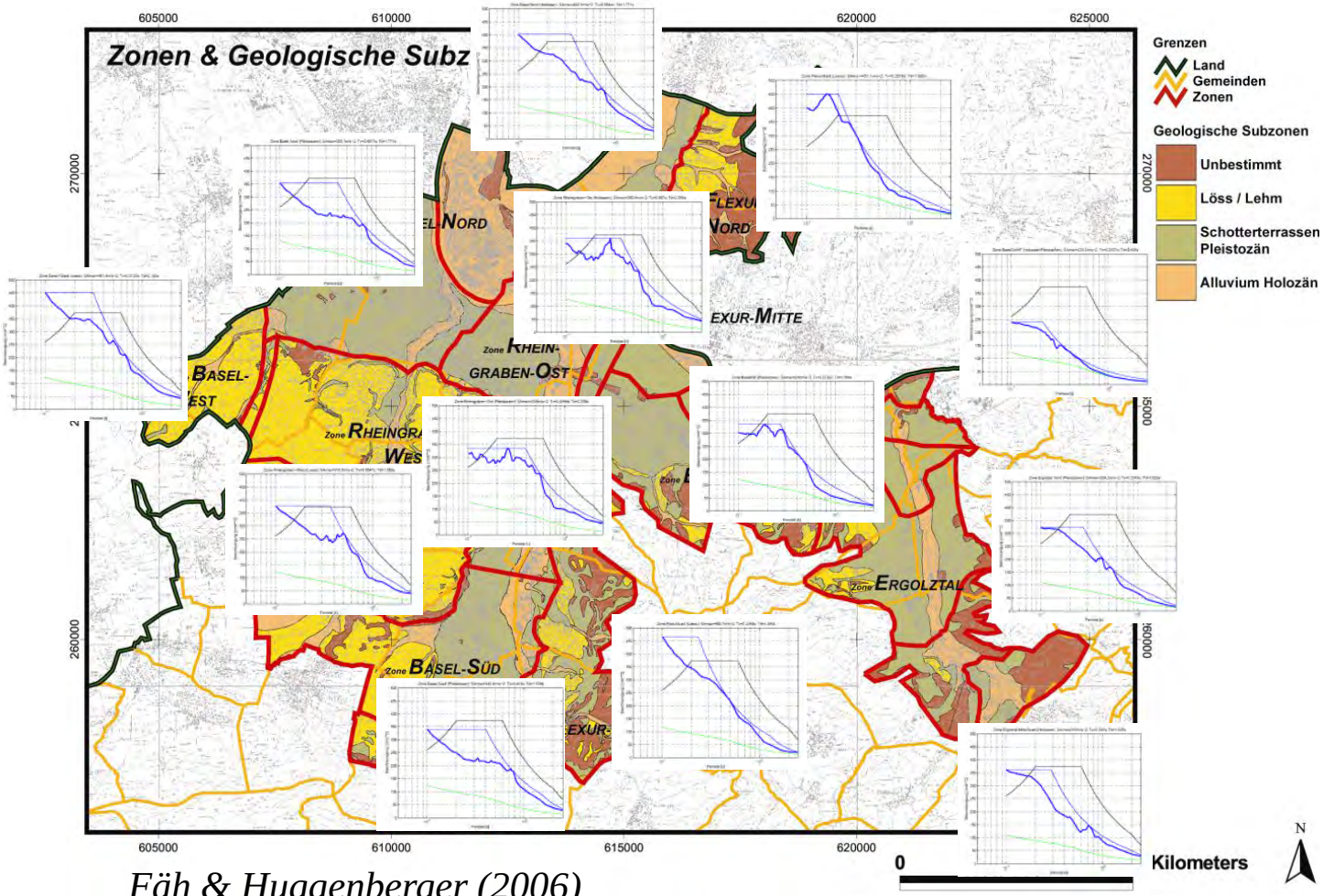




How to make the assessment more site-specific?

Example: microzonation for wider Basel region (2003-2009):

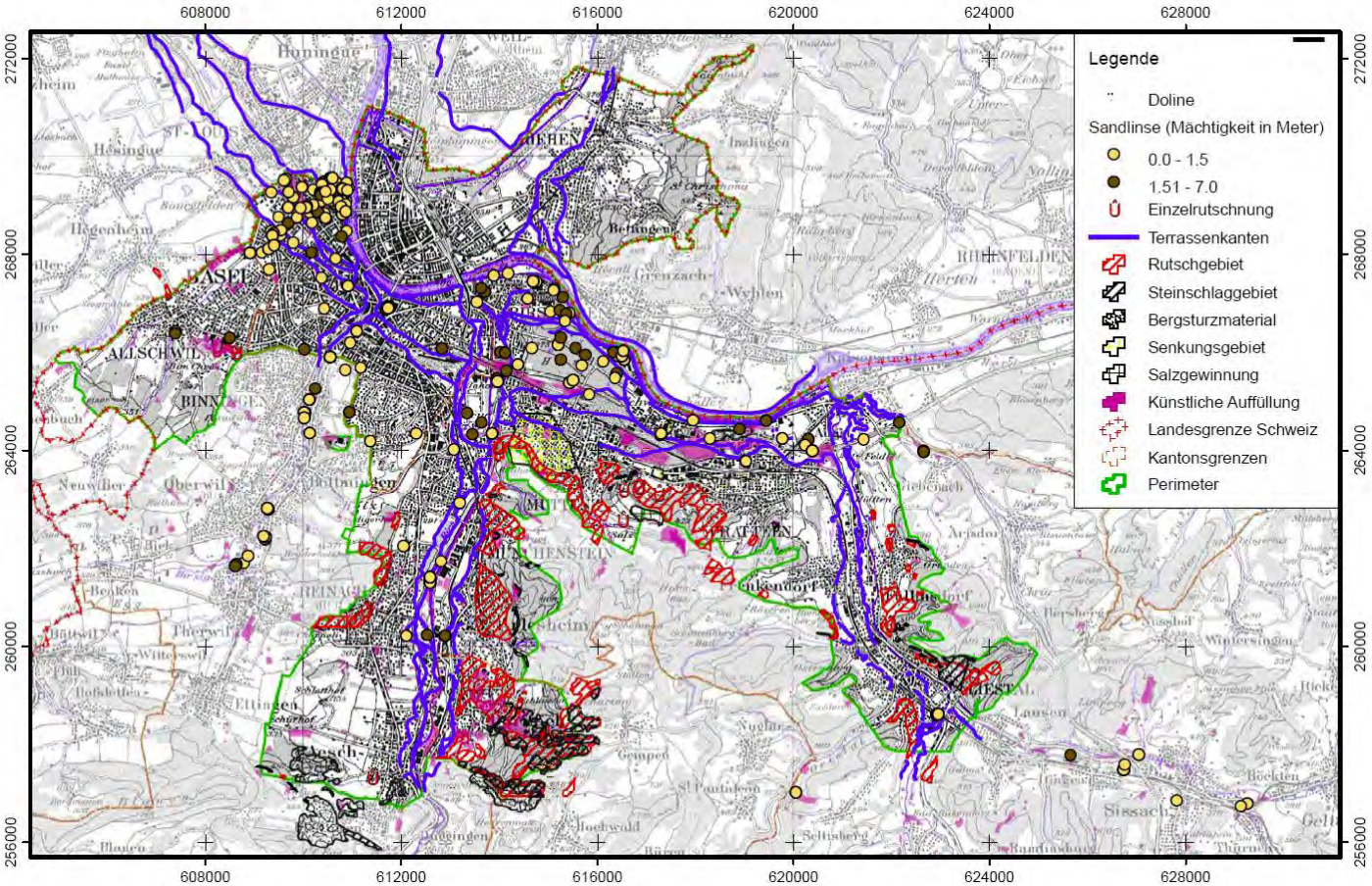
- Design spectra based on all layers/information
- Including conservative choices to cover uncertainties



Fäh & Huggenberger (2006)

How to make the assessment more site-specific?

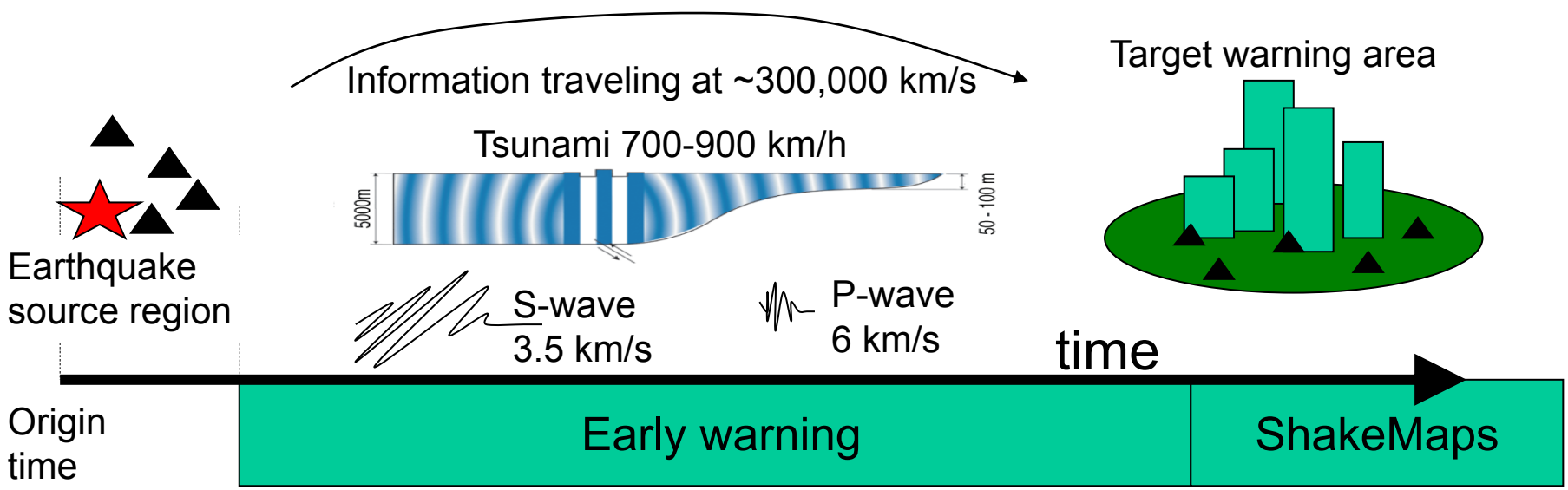
Map and model possible induced effects: Liquefaction, Settlements, Landslides, Tsunamis, Fire…



Fäh & Huggenberger (2006)

Recommendations

- Continuous improvement of seismic hazard and risk products
- Include natural and induced seismicity (oil, gas, water, geothermal energy)
- Inform the population & decision makers to increase awareness
- Land-use planning based on seismic zonation and direct & indirect risks
- Implement building codes and verify procedures
- Assess all possible impacts and prepare for different scenarios
- Secure escape towers (tsunamis) and safe buildings (lifelines)
- Implement early warning systems, communication networks & shakemaps



Thank you

Illustration of the 1584 earthquake at Aigle (CH)