Seismic Hazard Assessment of Switzerland, 2004

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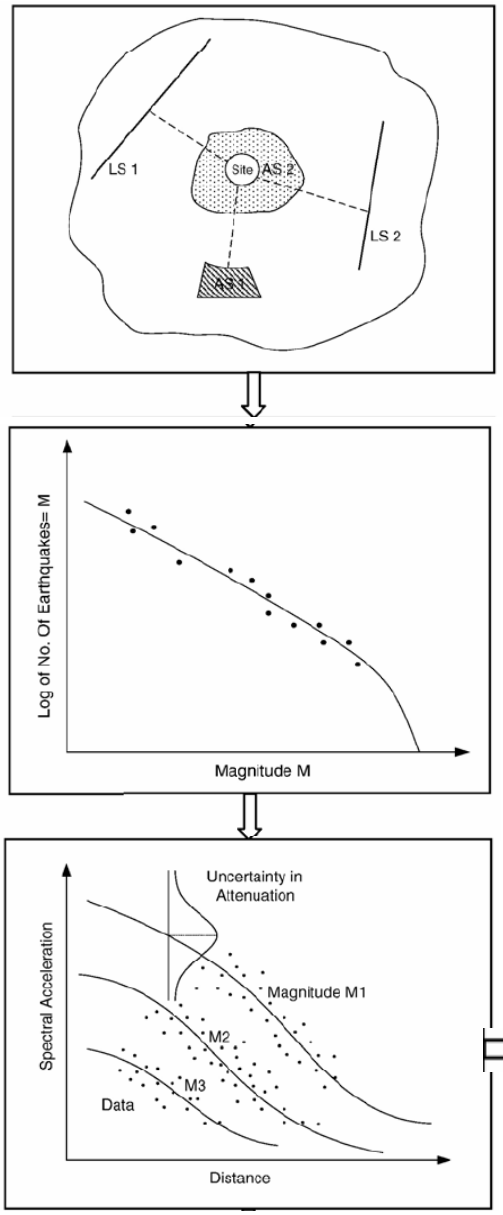
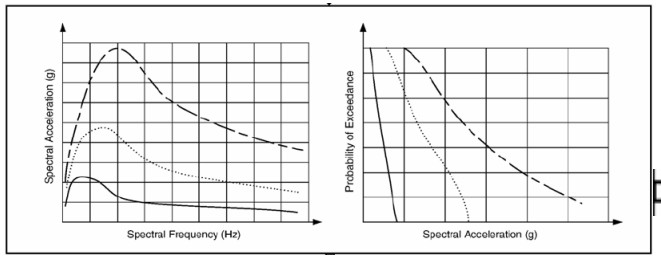
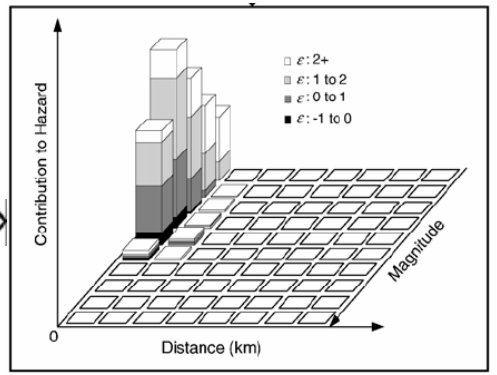
Outline



- Definition of earthquake sources
- Definition of seismic recurrence characteristics for each source
- Ground motion model including ground motion variability
- Hazard spectra for different probabilities of exceedance and development of hazard curves
- De-aggregation of hazard to develop controlling scenario events defined by magnitude distance pairs



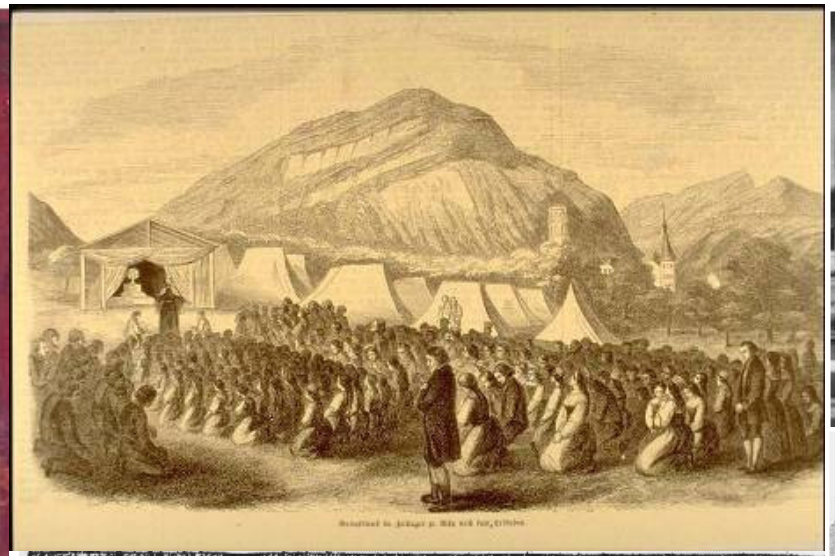


Work flow for a modern PSHA study following the Cornell-McGuire model

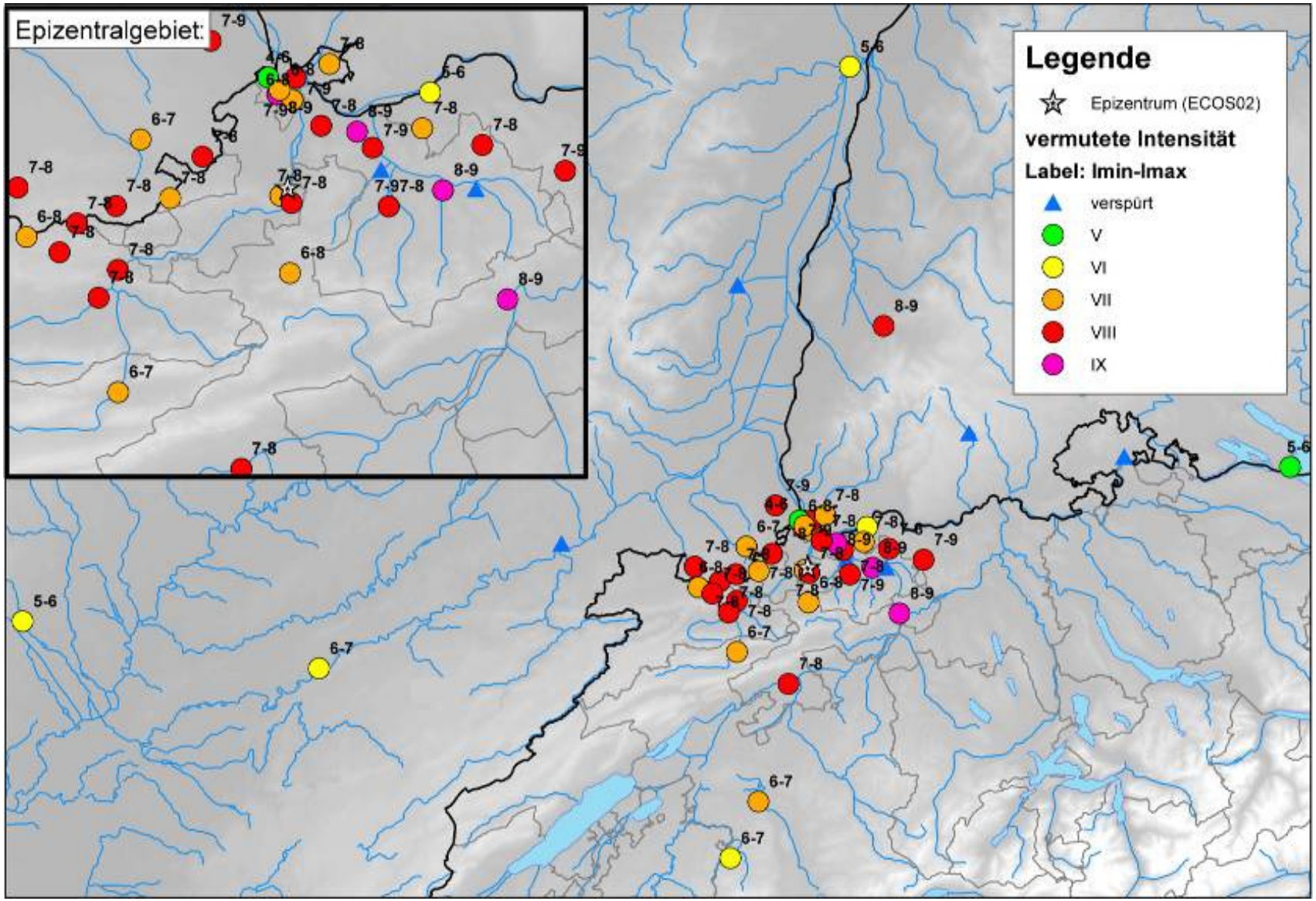
Definition of earthquake sources

- Historical observation
- Paleoseismic observation
- Instrumental observation
- Earthquake catalog
- Recurrence parameters (completeness)
- Declustering

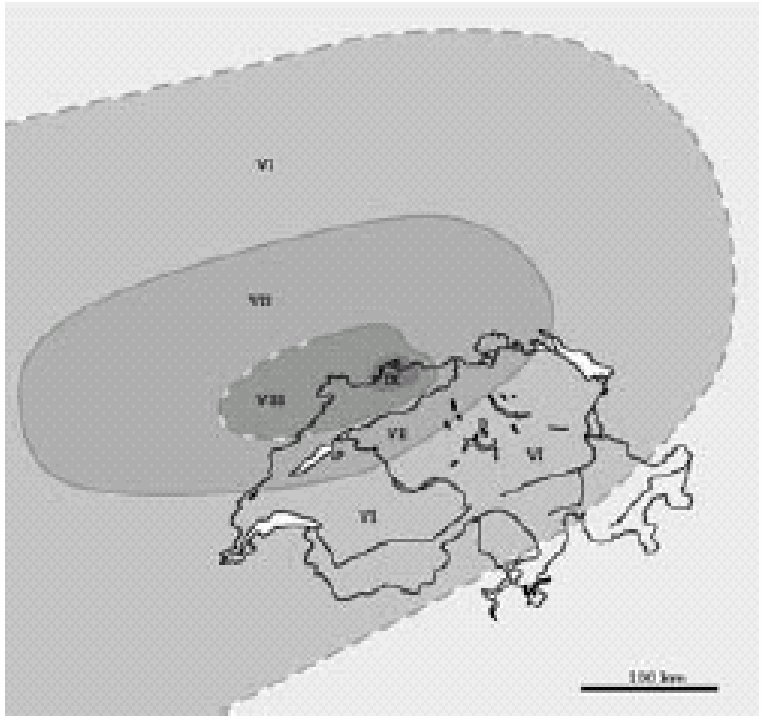
Swiss historical record



Basel, October 18,1356

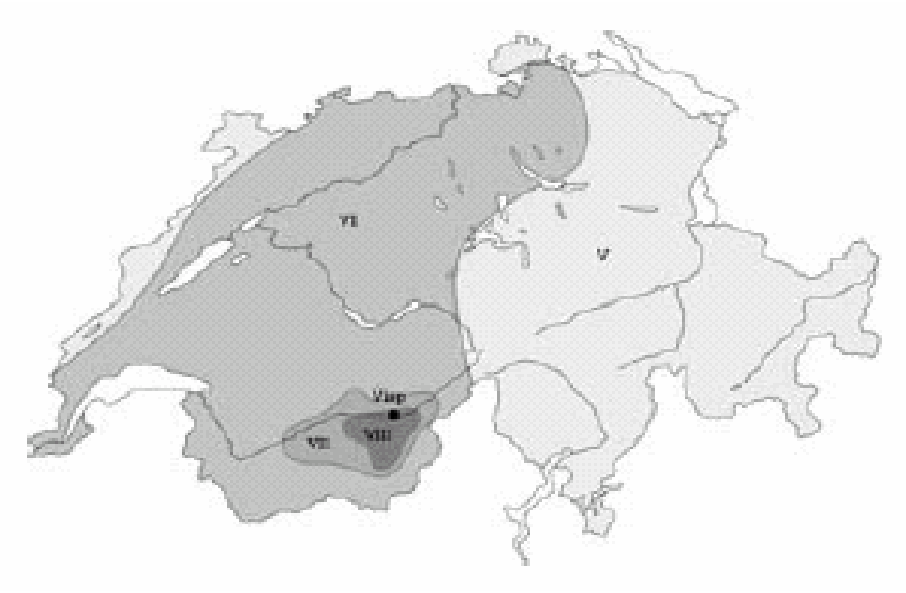


Macroseismic Record



1356, M6.9, Basel

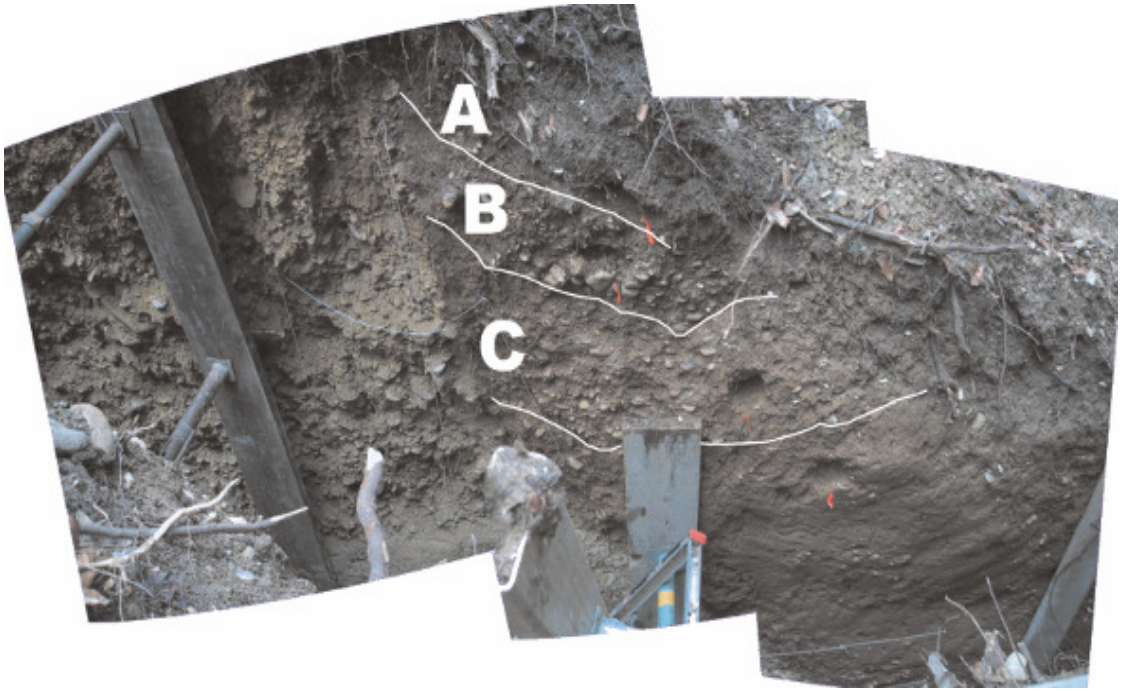
1855, M6.4, Visp

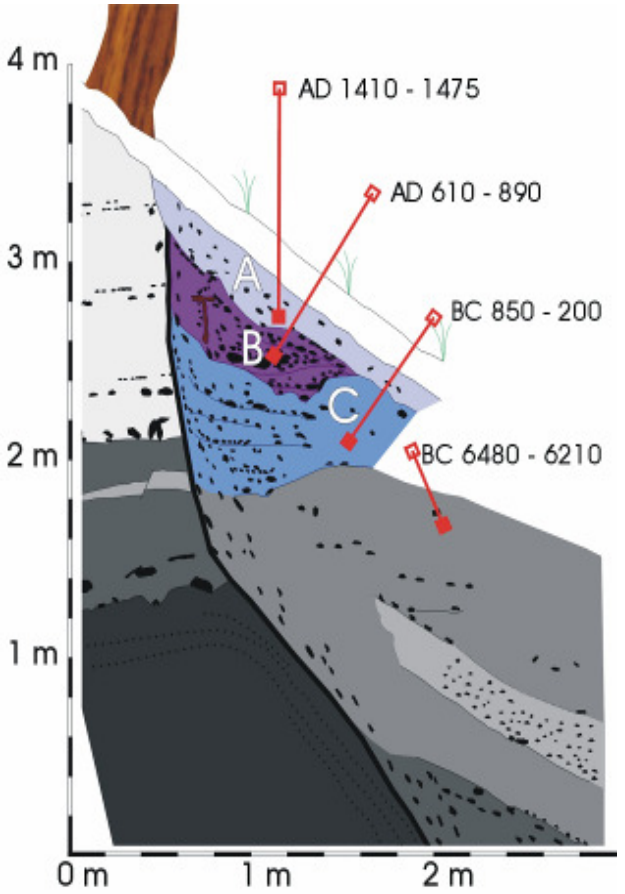


Reinach fault: westward view

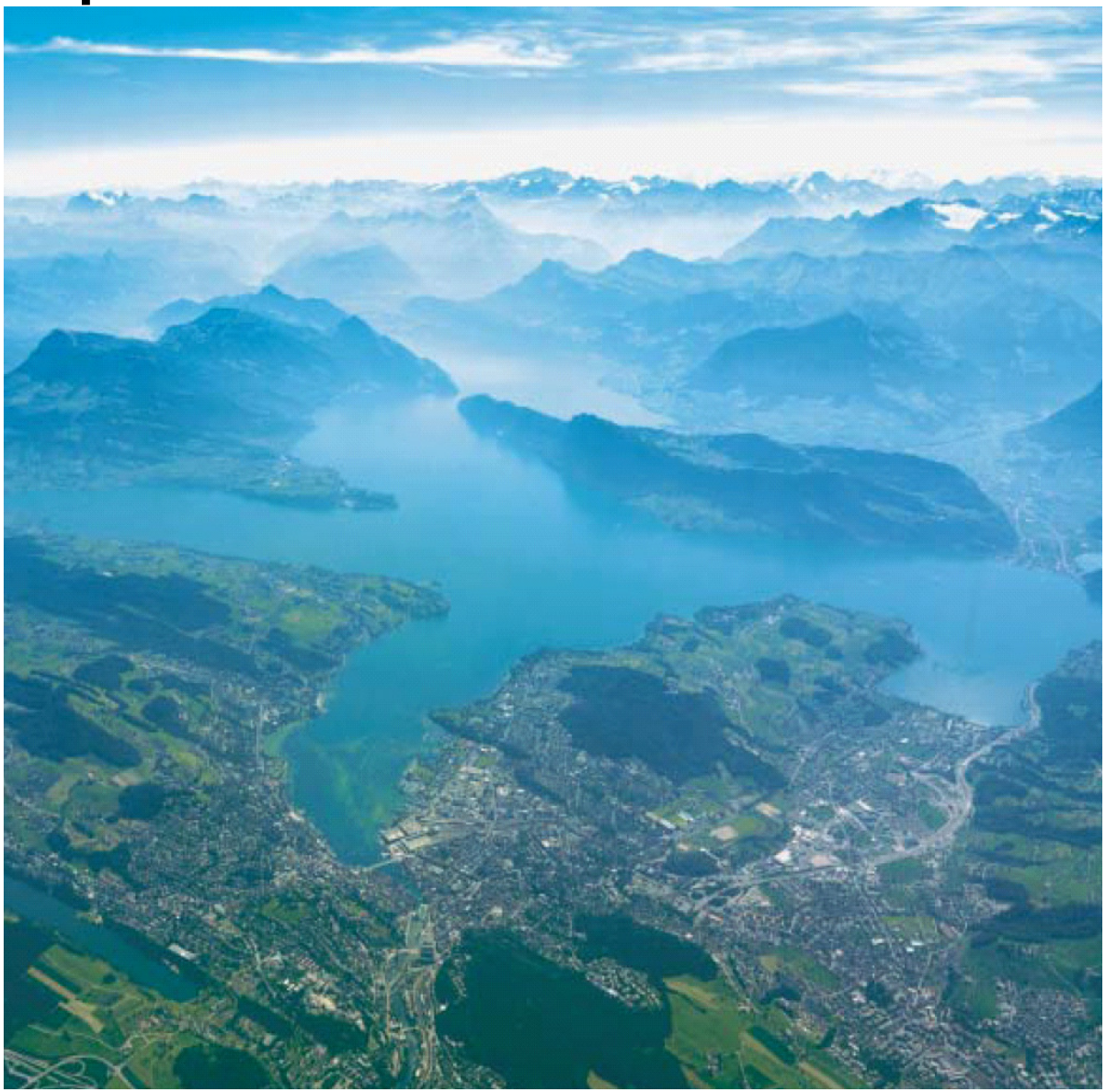
Reinach fault: trench view

Paleoseismology on the Reinach fault





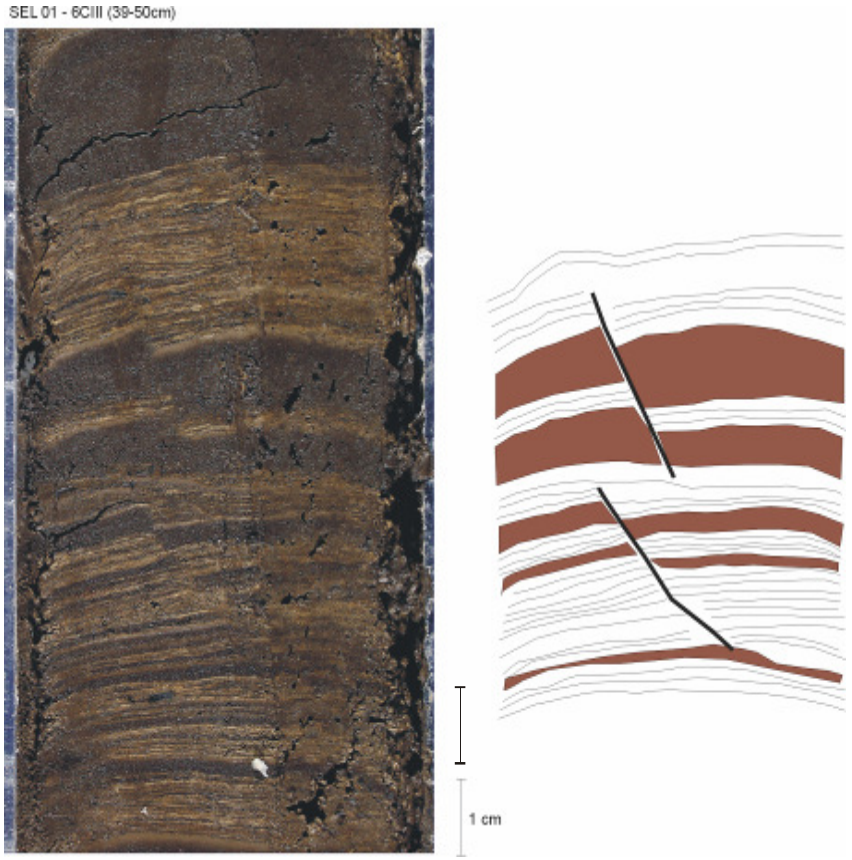
Earthquake record in Swiss lakes



Drilling lake sediments

Details from lake Seewen cores

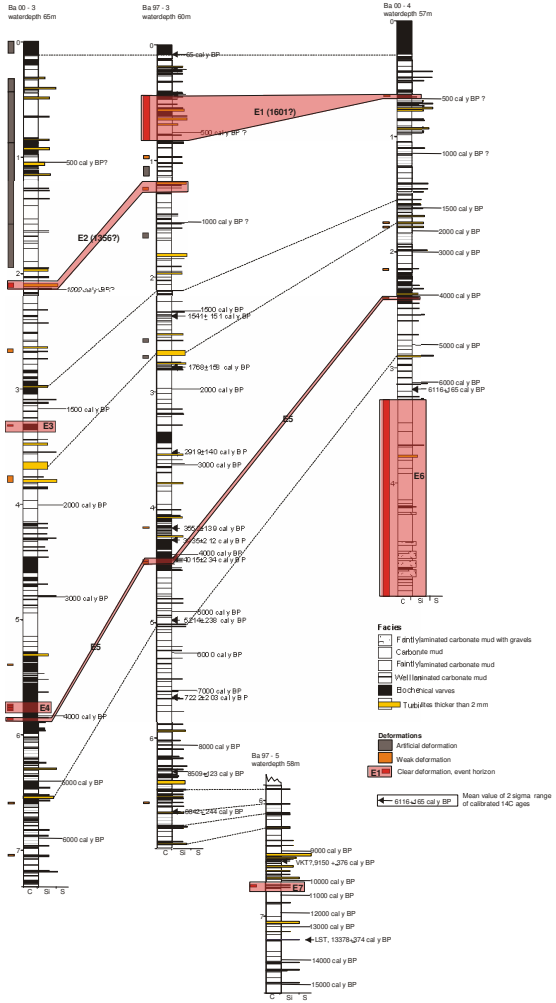
sand dyke



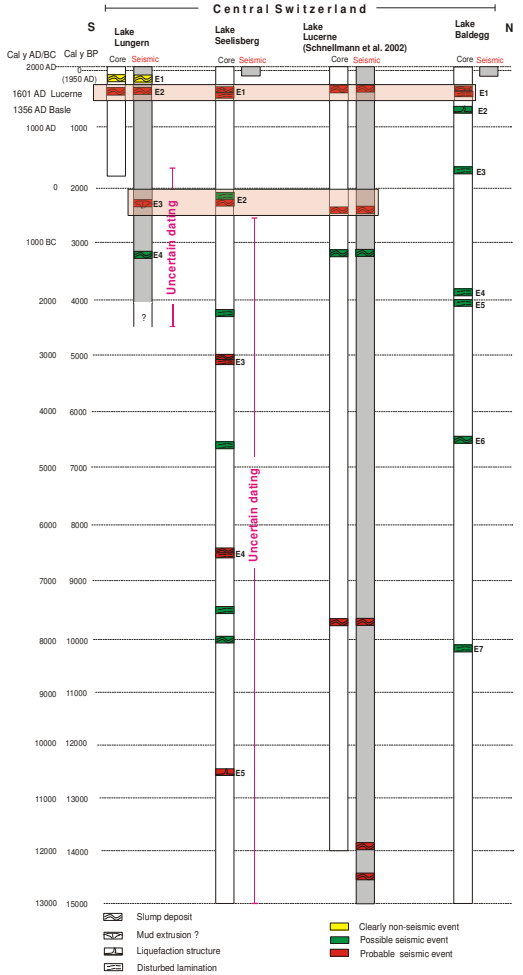
tilted, disrupted and deformed layers

sand injection

Correlating events

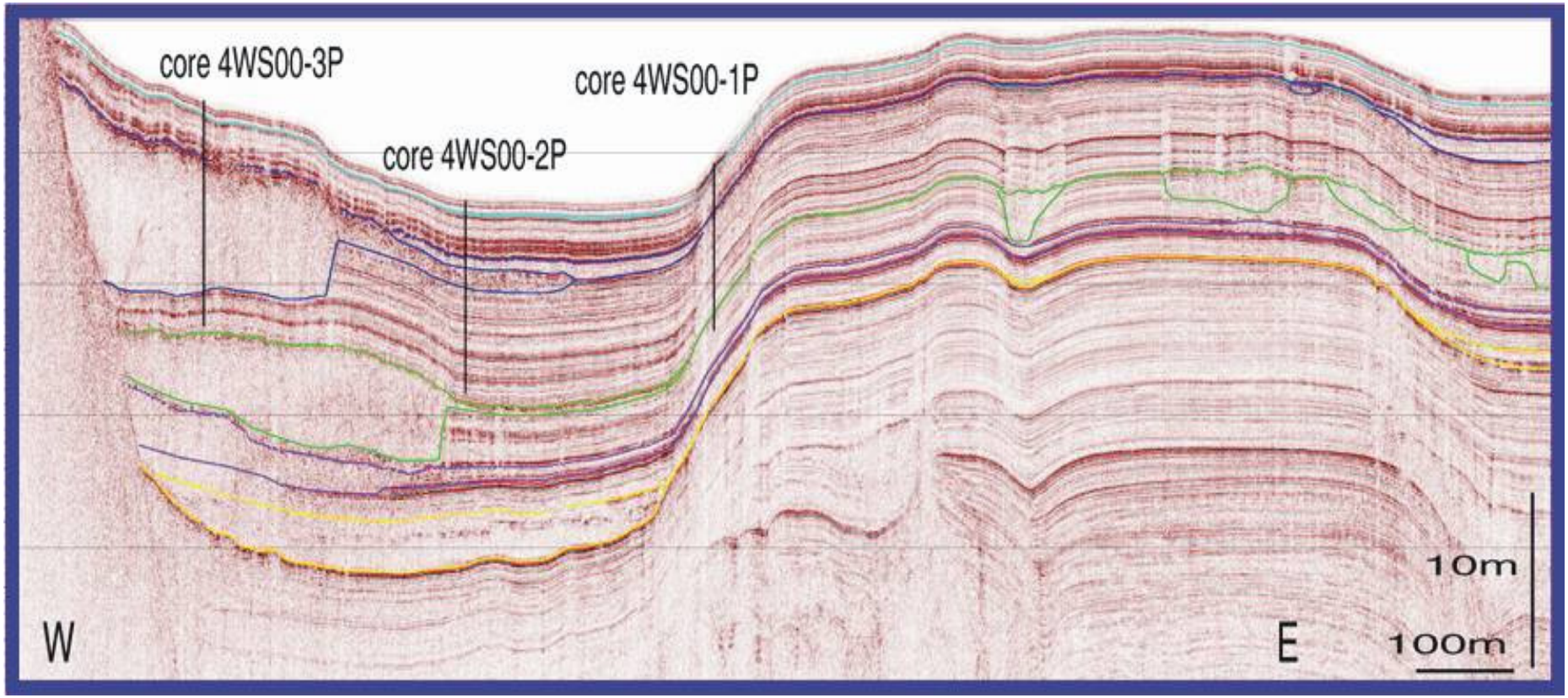


4 holes in Lake Baldegg



4 lakes in C. Switzerland

Paleoseismology, slumps in Lake Lucerne

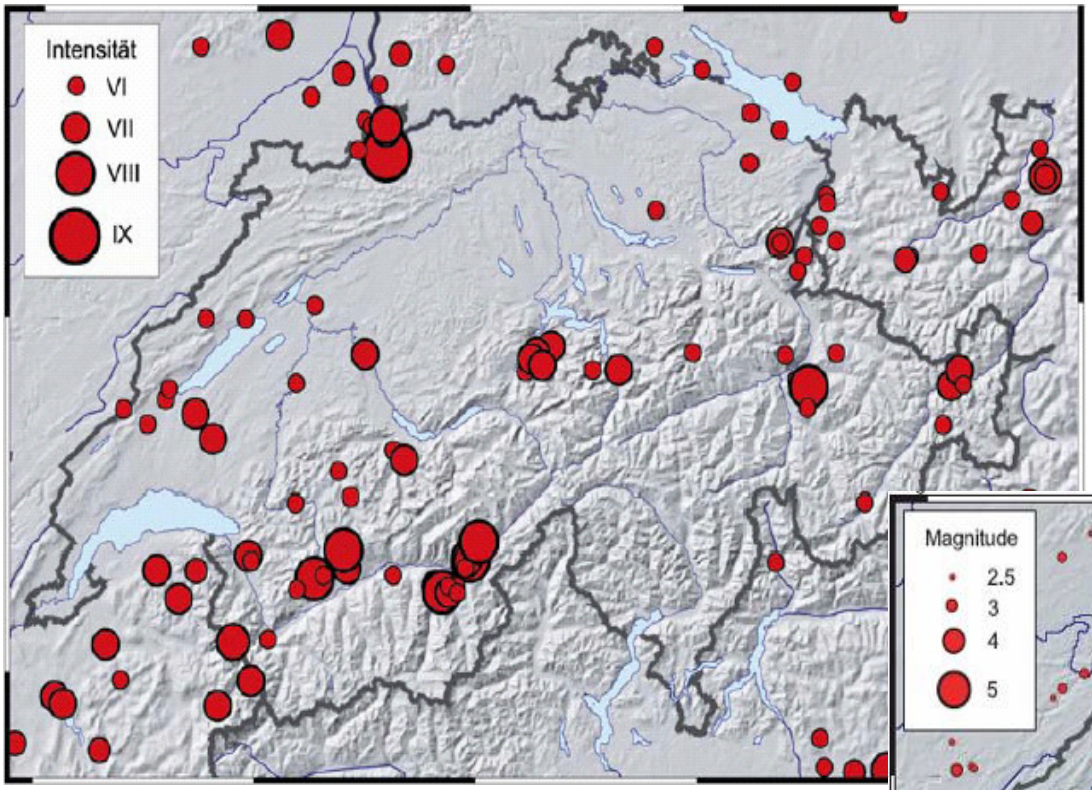


Dating rockfalls in the Basel area

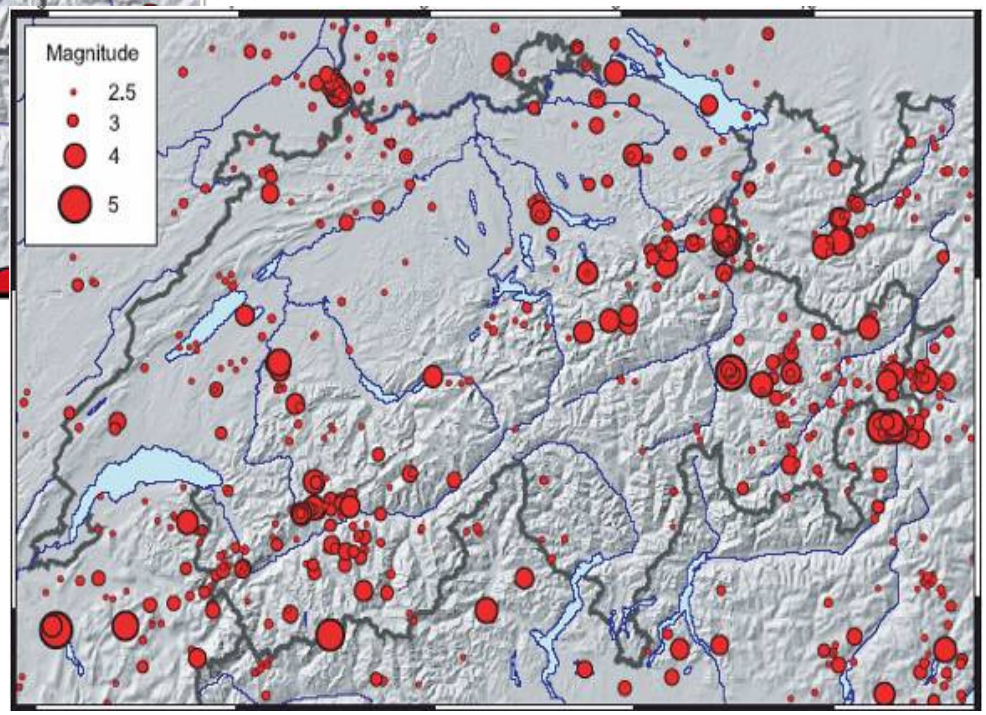
Dating rockfalls in the Basel area

Dating collapses in caves

Earthquakes in Switzerland

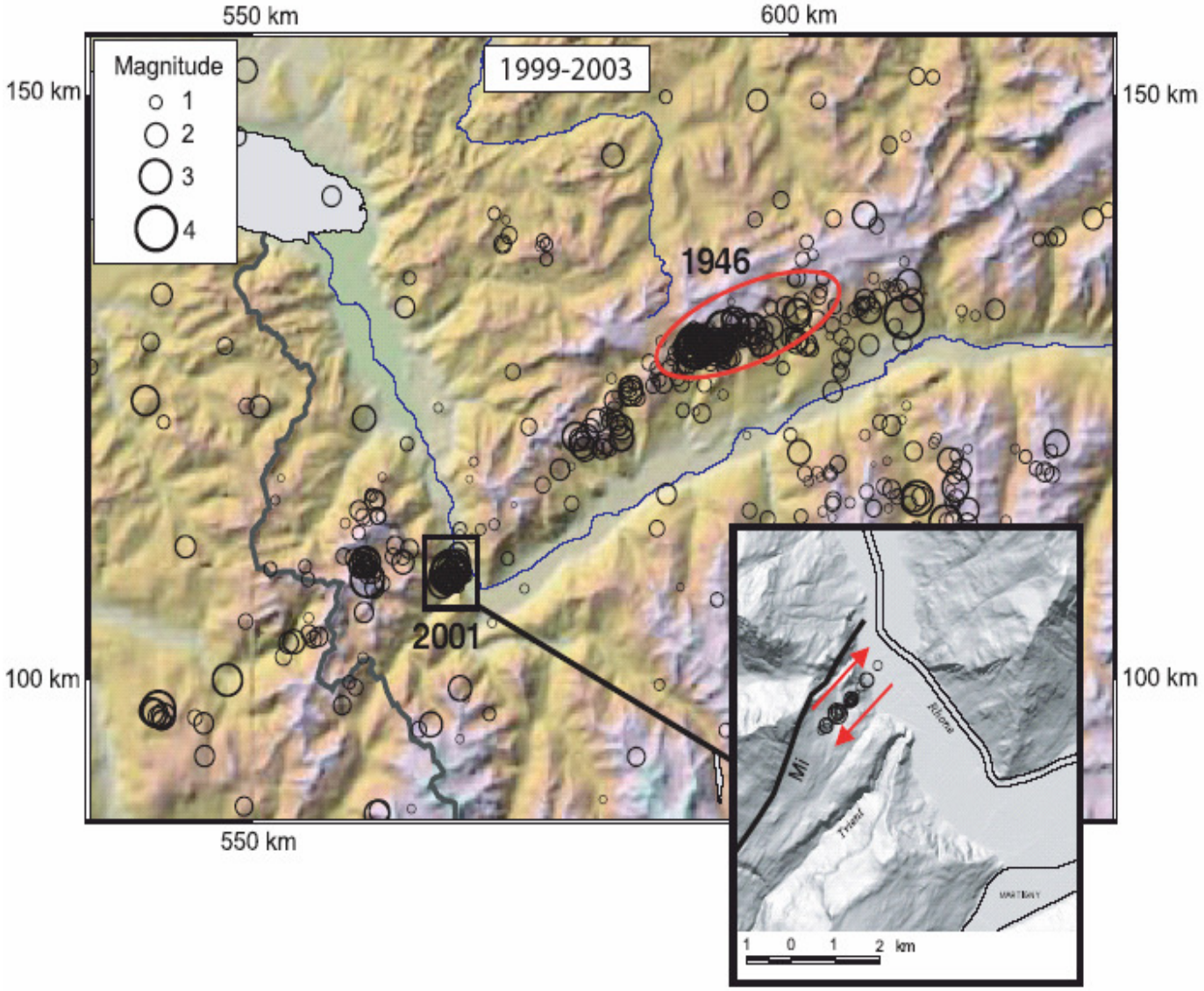


Macroseismic
1000-2004

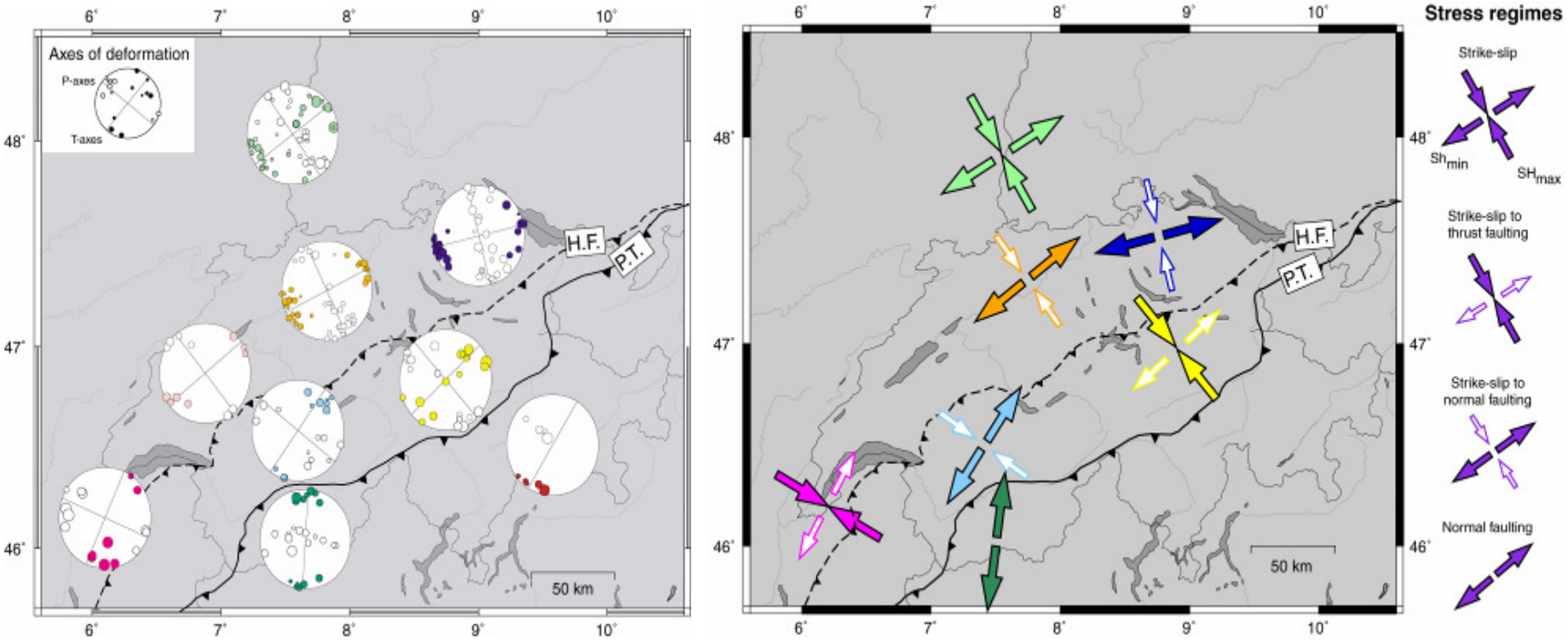


Instrumental
1975-2004

High-precision earthquake location

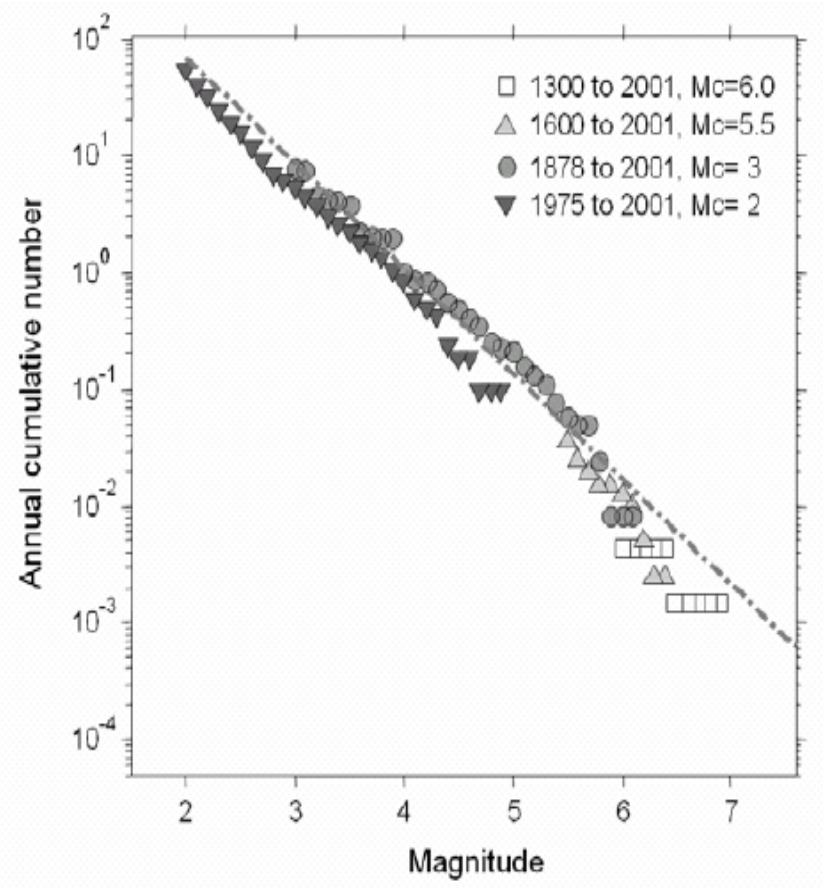


Seismic strain and stress

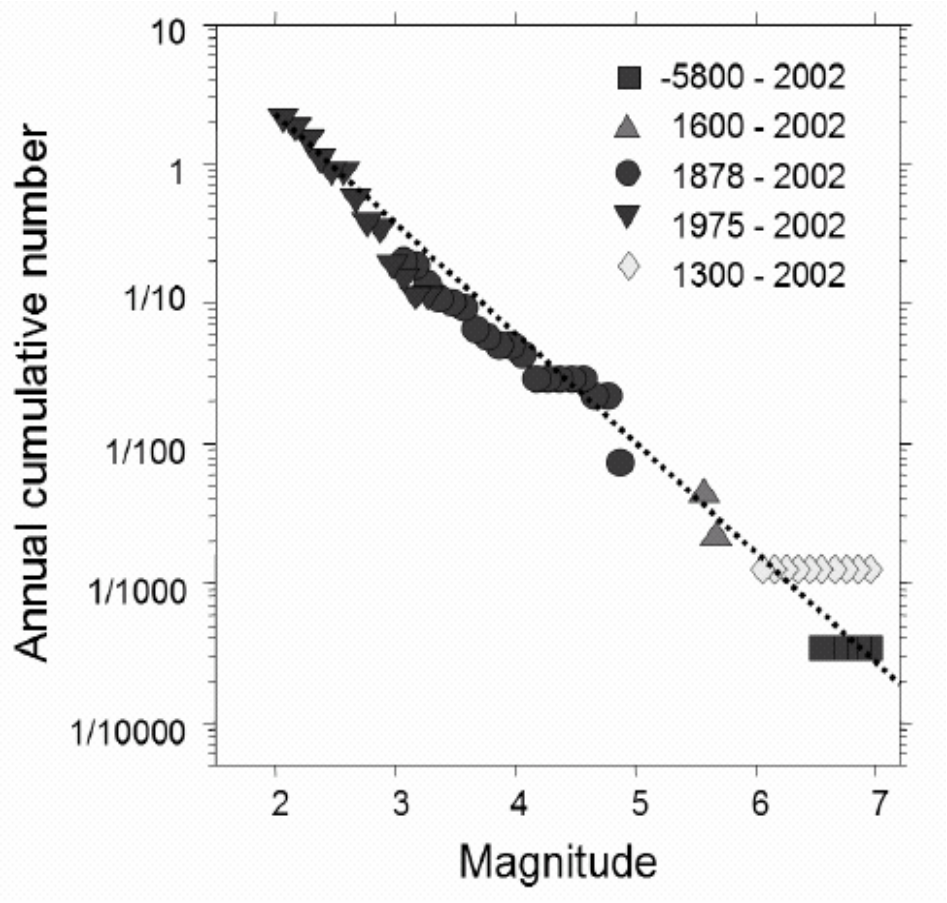


Activity rates

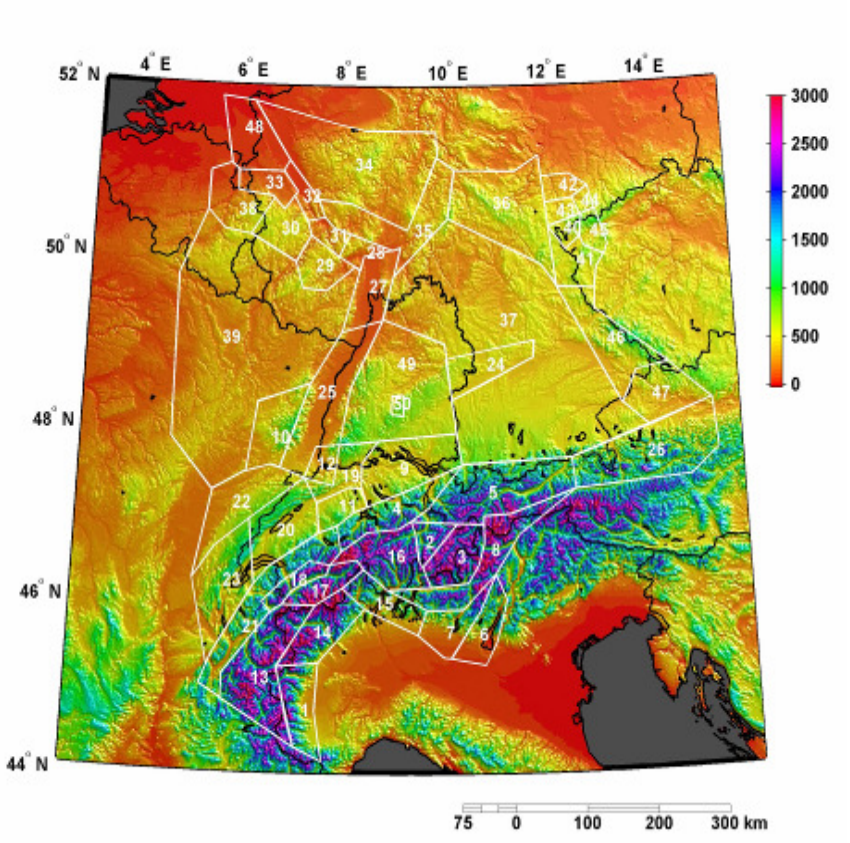
Switzerland

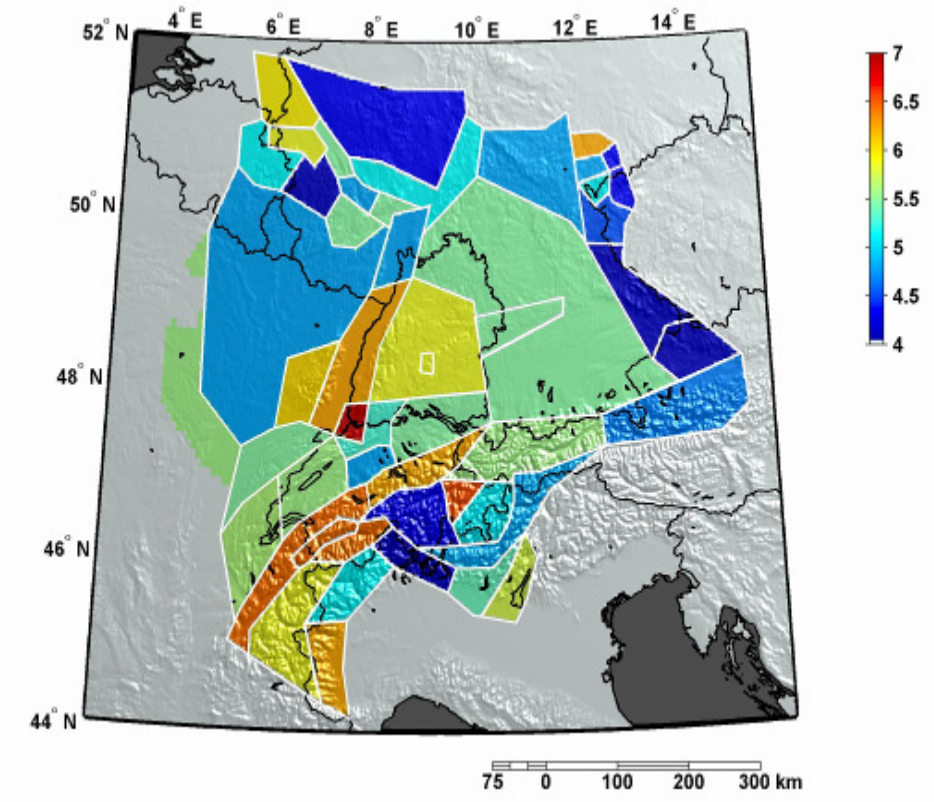


Basel area

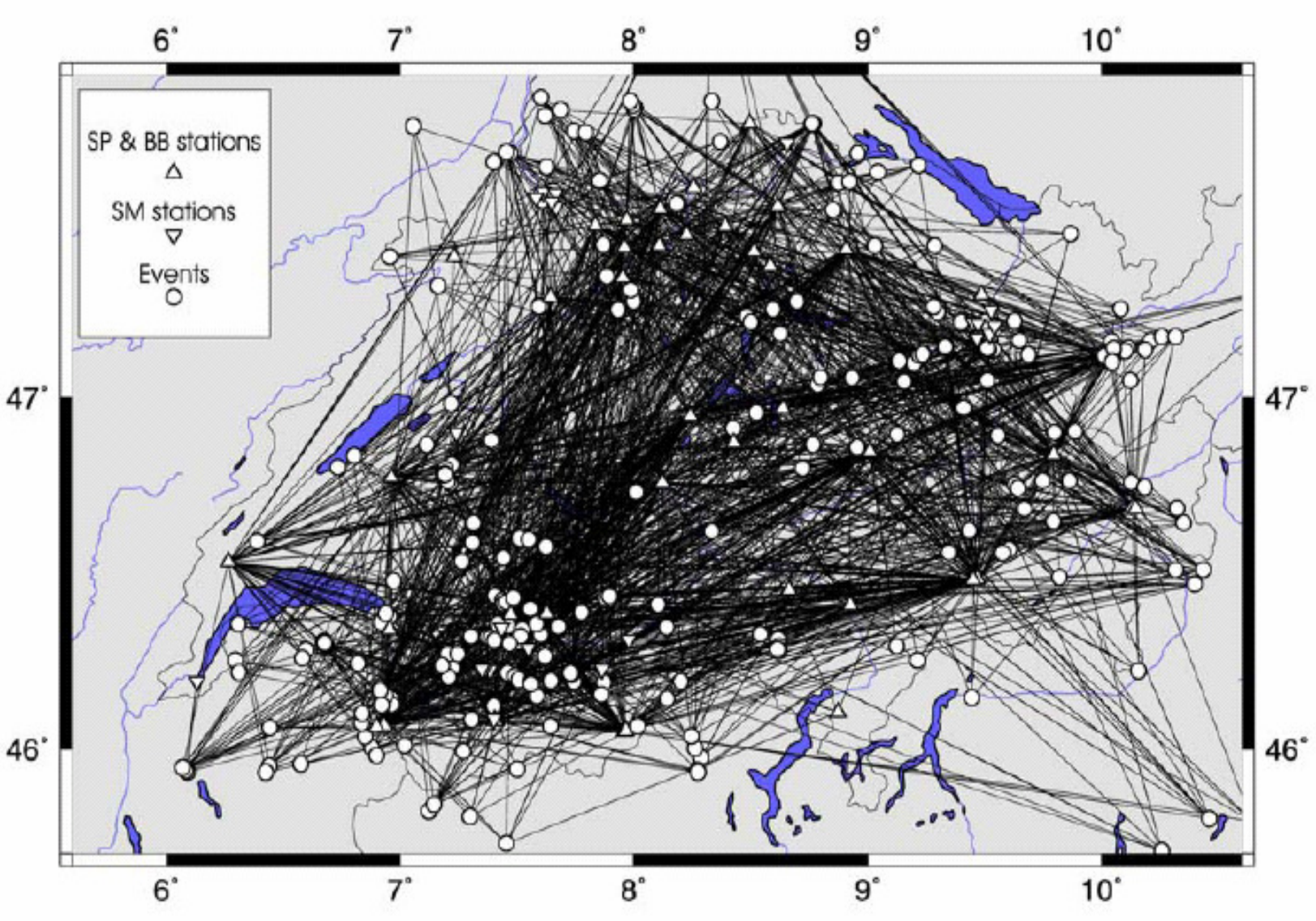


Seismic source zones and Mmax

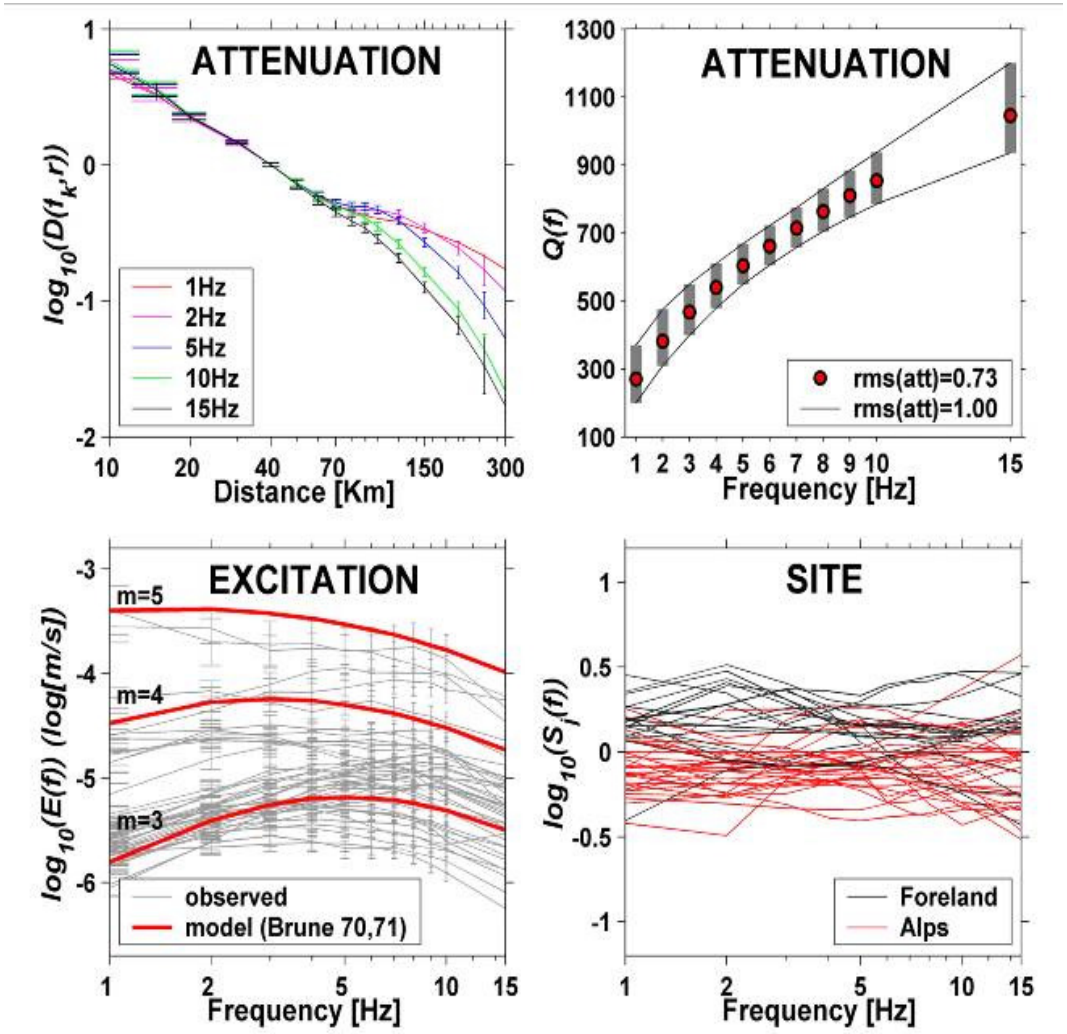




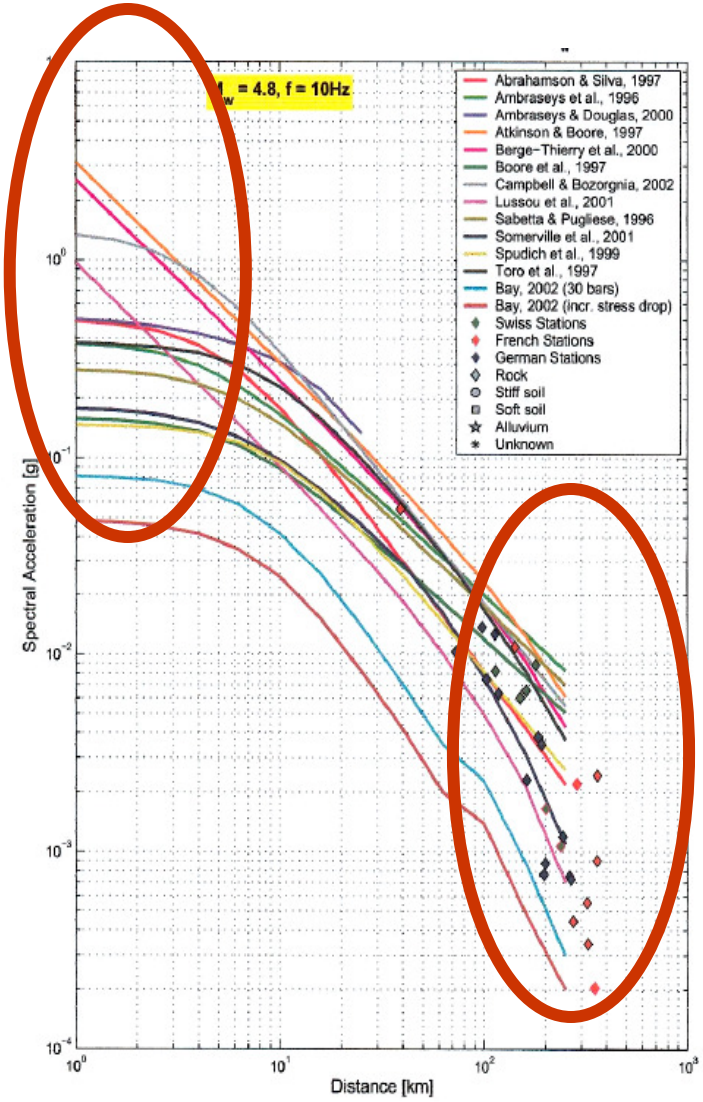
weak-motion attenuation



SED attenuation model



Uncertainty in strong-ground motions

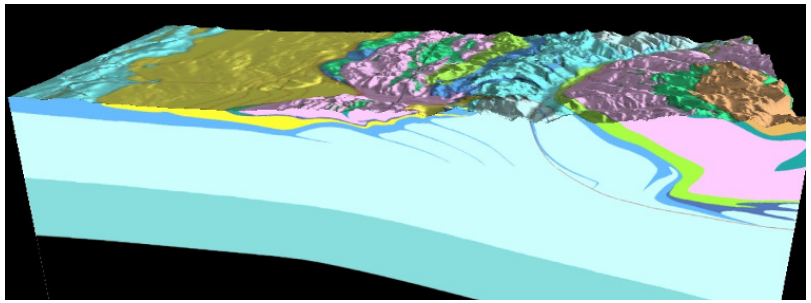


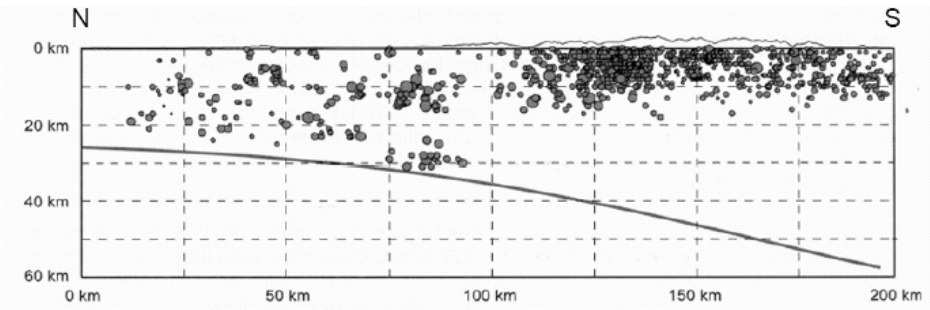
The process of hazard computing

- Montecarlo simulation approach

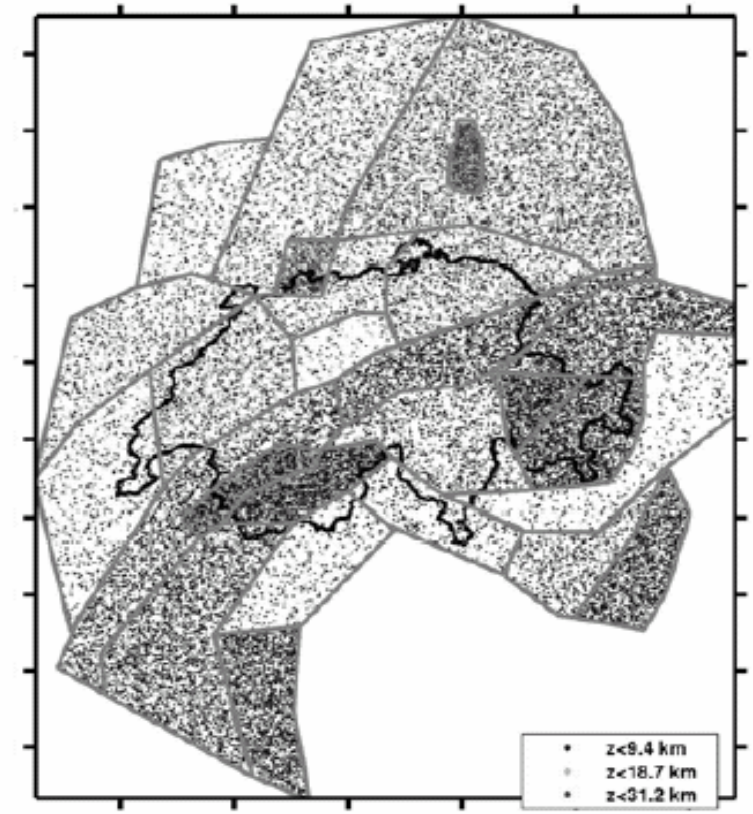
  - Create a synthetic catalog of earthquakes
  - Spans 1 million years, magnitude >4, -> 2 million events
  - Depth is given
  - Alternative models and their weighting are considered by creating subcatalogs

  - This procedure is repeated for all nodes evenly spaced on a 5 x 5 km spaced grid covering Switzerland

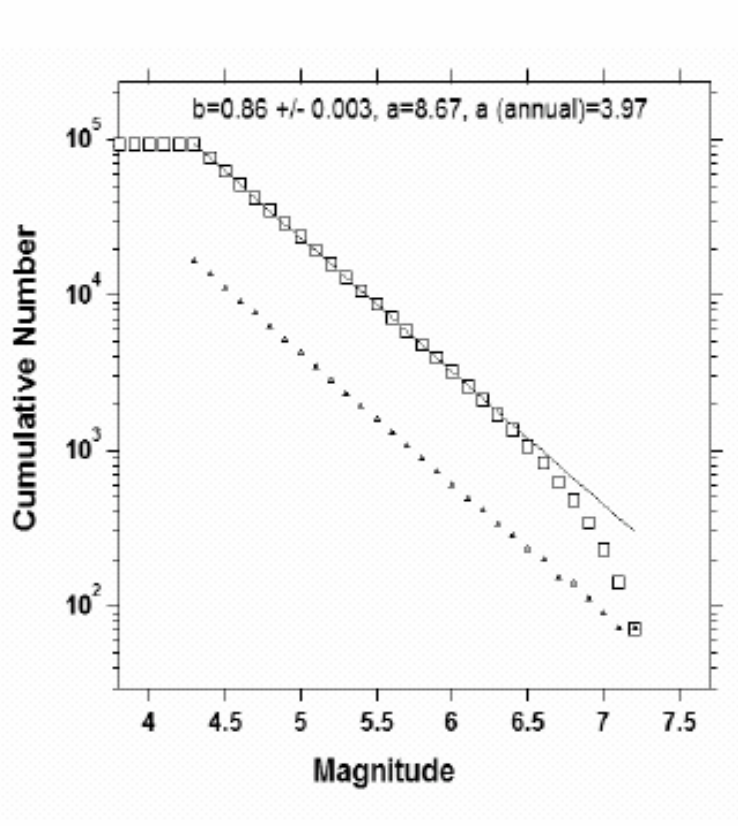




The process of hazard computing



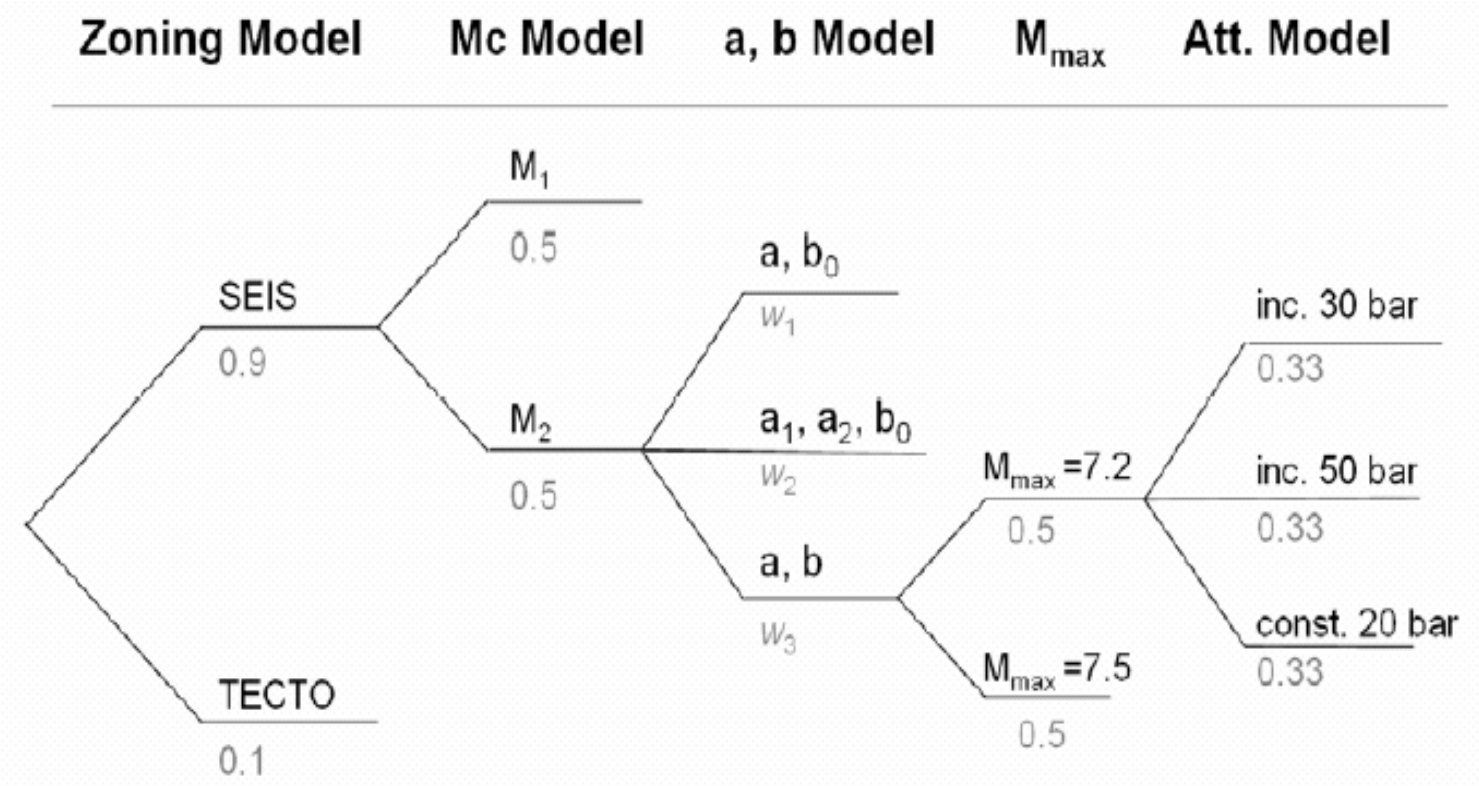
Map of epicenters and source zones used



Cumulative frequency-magnitude distribution of events

The process of hazard computing

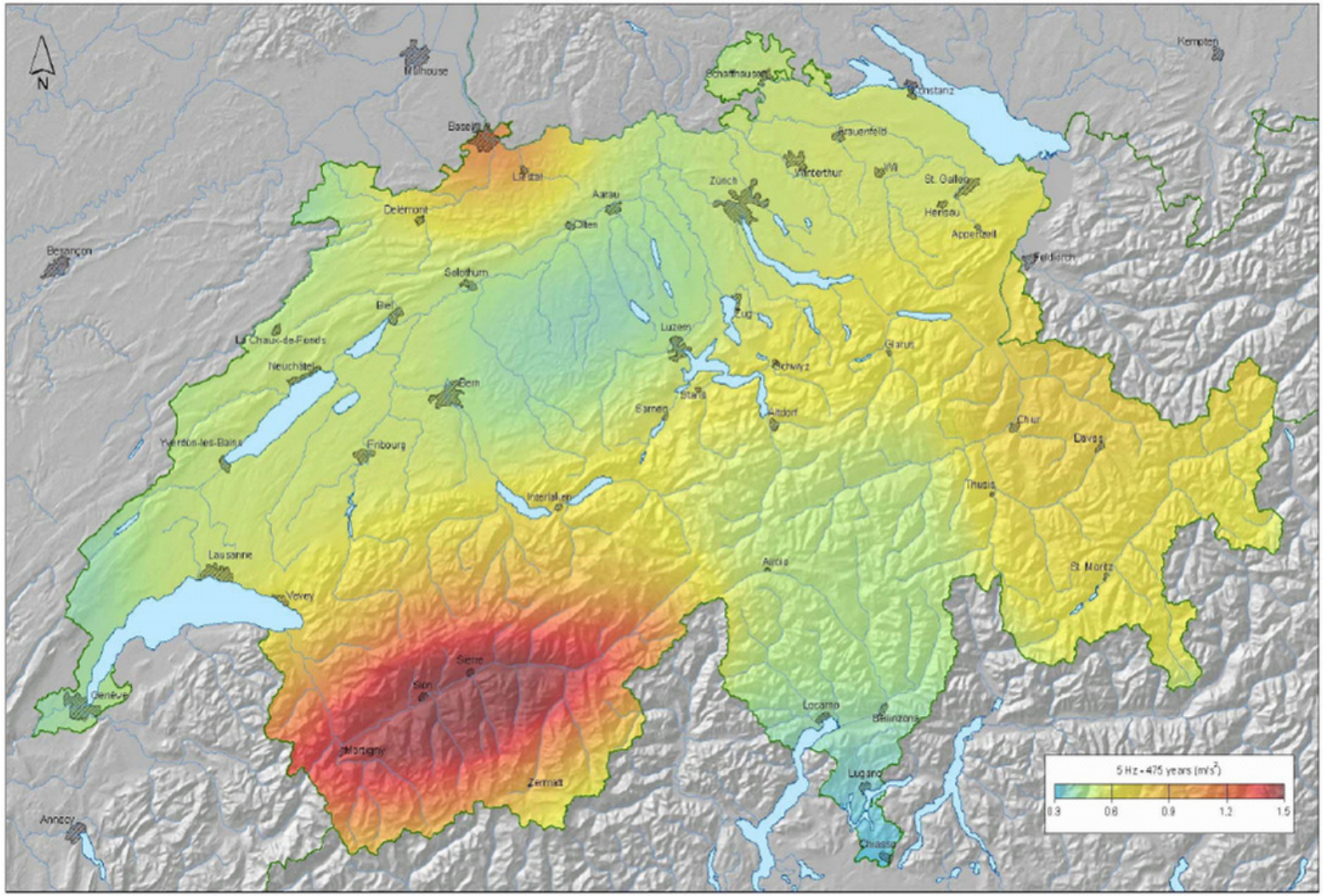
Logic tree : epistemic vs. aleatory



Variability and Uncertainty

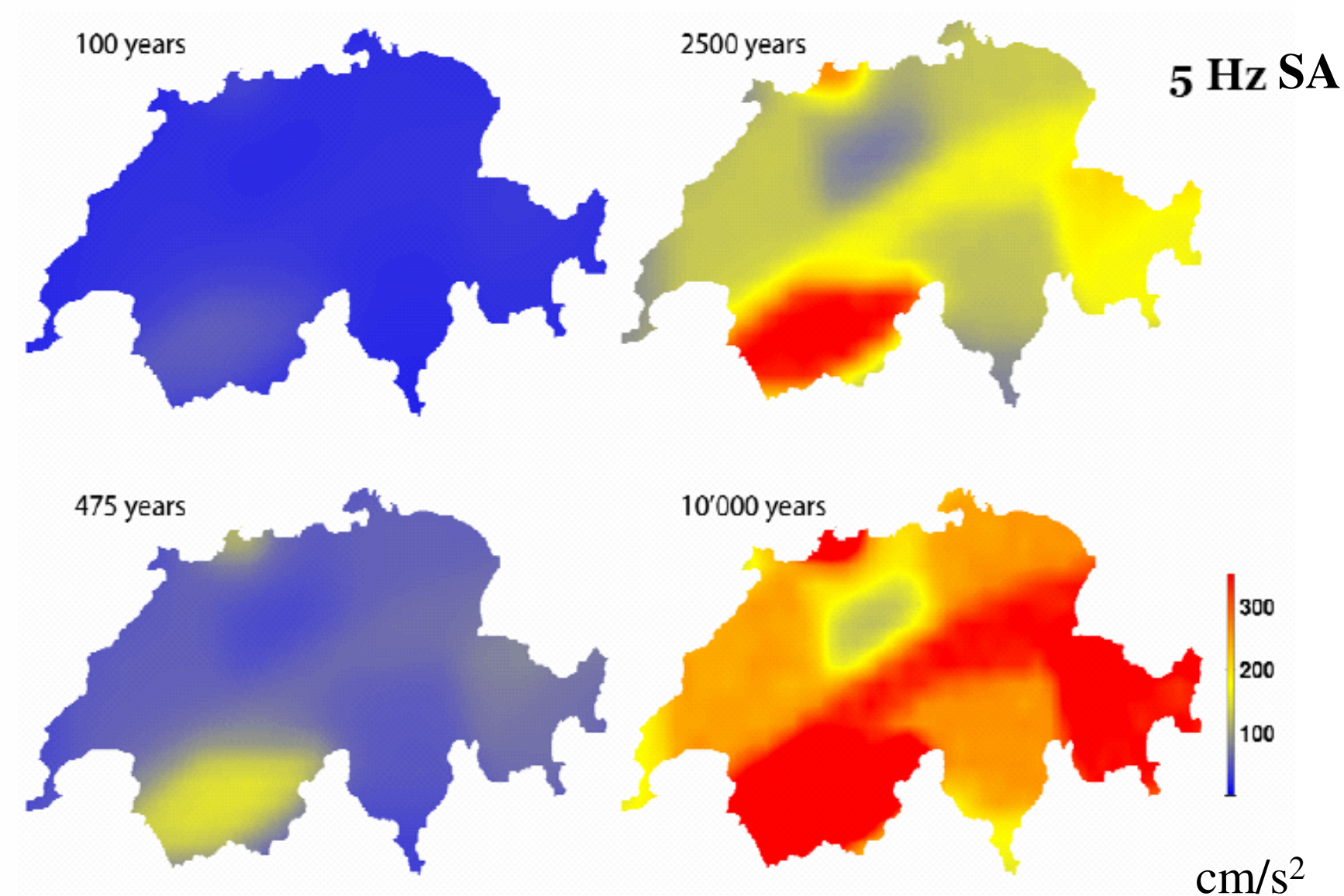
- Aleatory Variability
  - Natural randomness in a process
  - Accommodated in the hazard integral
  - Affects the shape of the hazard curve
- Epistemic Uncertainty
  - Scientific uncertainty in our models of the process
  - Incorporated through logic trees
  - Leads to alternative hazard curves (fractiles)

Seismic Hazard of Switzerland

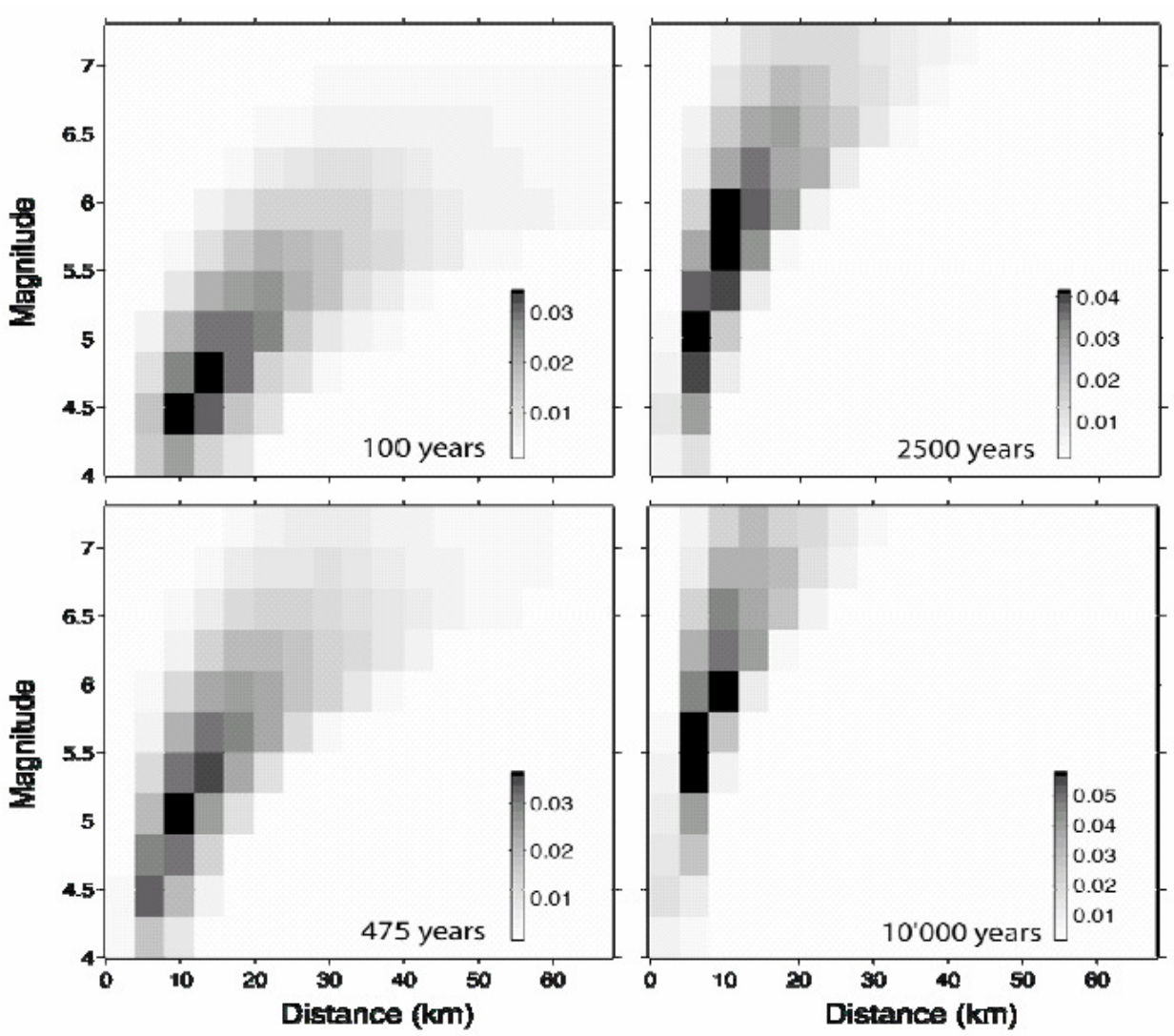


5% damped horizontal acceleration response spectrum, 5Hz, 475 yr

Seismic hazard of Switzerland



Hazard de-aggregation, Basel



Conclusions

PSHA is improving rapidly, and requires todays multi-disciplinary competences, multiple expert elicitation, cross-border cooperation

Regional PSHA is not yet stable

Local hazard and simulation hazard are coming, and will soon replace regional PSHA in several regions – i.e. Alpine valleys, selected cities

We need to focus on:

- near-fault shaking
- de-aggregating uncertainties
- calibrating for local conditions

We cannot continue to work at national level only, it is time to have in Europe a reference hazard model(s)