COUPLED SEISMOGENIC GEOHAZARDS IN ALPINE REGIONS (COGEAR)

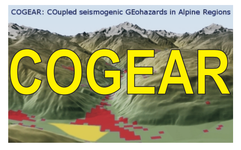
cces Competence Center Environment and Sustainability

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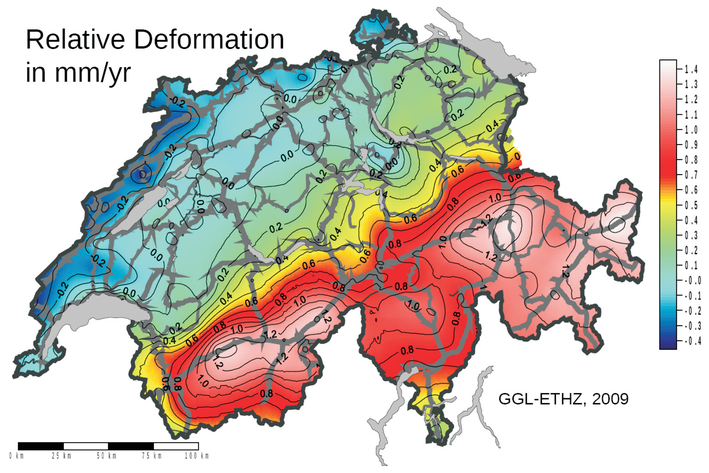
Schweizerischer Erdbebendienst Swiss Seismological Service



Abstract

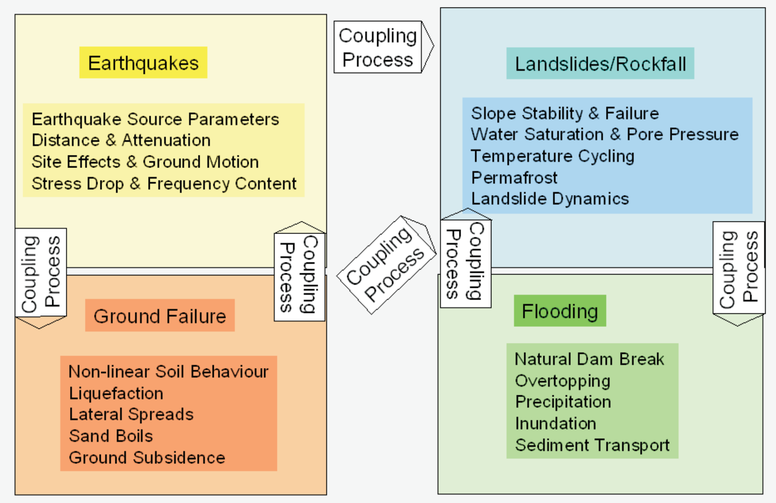
COGEAR is an interdisciplinary natural hazards project investigating the hazard chain induced by earthquakes. It addresses tectonic processes and the related variability of seismicity in space and time, earthquake forecasting and short-term precursors, and strong ground motion as a result of source and complex path effects. We study non-linear wave propagation phenomena, liquefaction and triggering of landslides in soils and rocks, as well as earthquake-induced snow avalanches. The Valais, and in particular parts of the Rhone, Visper, and Matter valleys have been selected as study areas. Tasks include detailed field investigations, development and application of numerical modeling techniques, assessment of the susceptibility to seismically induced effects and installation of different monitoring systems to test and validate our models. These systems are for long term operation and include a continuous GPS and seismic networks, a test installation for observing earthquake precursors, and a system to study site-effects and non-linear phenomena in two test areas (Visp, St. Niklaus-Randa). Risk-related aspects of impacts on buildings and lifelines are also considered.

Before an Earthquake



COGEAR project goals:
1) Where and how large are the active faults?
2) Can we observe precursors **over longer times** or **shortly** before an event?

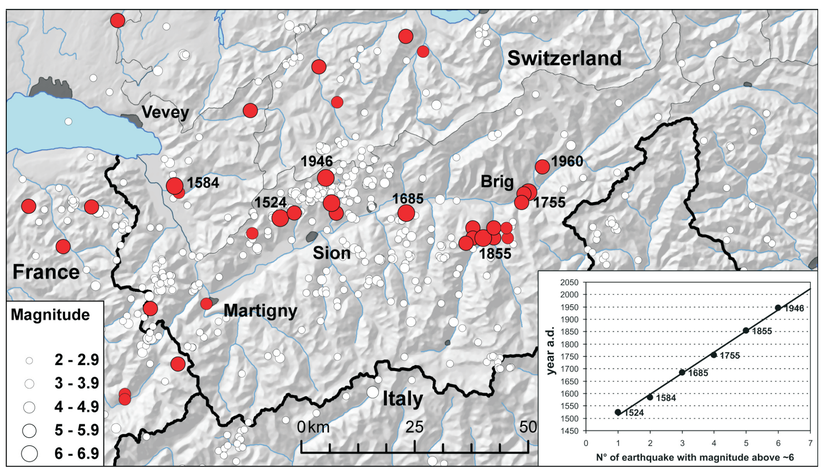
During an Earthquake



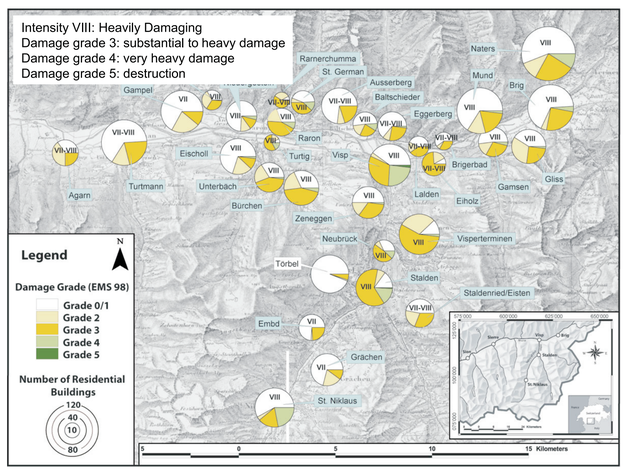
COGEAR project goals:
1) Modeling and observation of coupled processes.
2) Reduction of uncertainties in hazard and risk models.

Earthquakes in Valais (Switzerland)

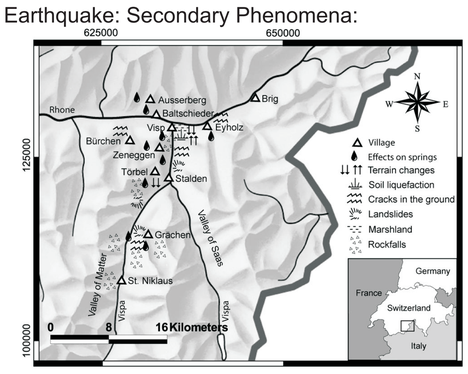
The Valais region in Switzerland, and specifically the area of Visp, as well as the Visper and Matter valleys have been selected. In the past, the Valais has experienced every 100 years a magnitude 6 or larger event, with the last magnitude 6.1 earthquake in 1946. The region of Visp is hit by damaging earthquakes every 40 years (Intensity VI-VIII), with the last nearby event in 1960 reaching a macroseismic intensity of VII. The strongest events in the Visp area occurred in 1755 (Mw=5.7) and 1855 (Mw=6.2). During all such events significant damage occurred from ground motion and different kinds of secondary phenomena such as liquefaction in the Rhone plain, slope instabilities and extended rock fall. Observed earthquake effects in the Valais in historical times were analyzed and compared to worldwide observation. This helps constrain worst-case scenarios of earthquake-induced landslides and their consequences. Analysis of seismo-tectonic structures in the Valais region is in progress, with the characterization of potentially active faults.



1855 Earthquake: Damage:



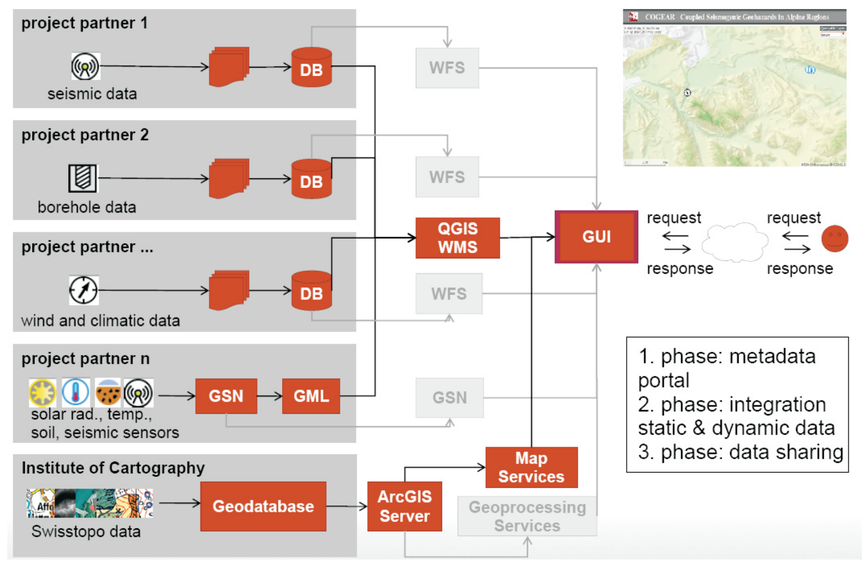
1855 Earthquake: Secondary Phenomena:



(Fritsche et al., 2006)

Common Database

The development of a common distributed database and GIS Platform is the first element of COGEAR. The concept of distributed data access allows for flexible, evolving database schemas that are adapted to the specific research tasks of the individual partners while allowing for low maintenance costs. The database has been successfully tested with all partners, and with its launch in January 2011, the GIS Platform will allow us to organize and access available research data of the project in an intuitive manner.

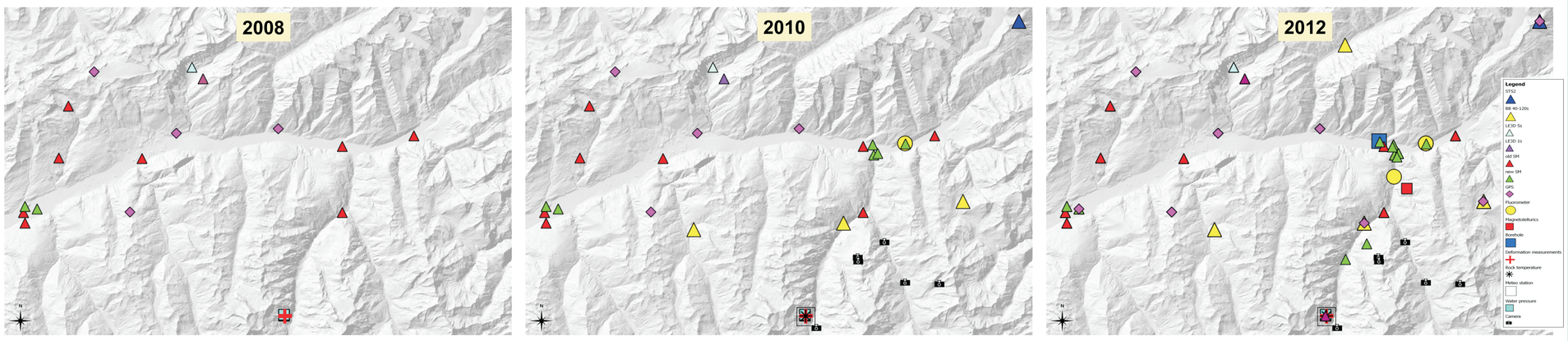


Principle of distributed data

Extending the Networks

In order to verify numerical models and improve our observational possibilities, a large number of instruments are installed in the multi-sensor framework of COGEAR. The present status and plan for the full system is shown in the figures. Densification of the high-gain seismic network in the region is almost complete. With the new stations, the seismic network is capable of locating earthquakes in the study area down to very low magnitudes. It is expected that GPS stations will be co-located at a number of these sites. The stations are complemented with the network of new strong motion stations in Visp and the Matter valley that will be used to test ground motion prediction models. For monitoring of unstable rock masses, a new fiber optic strain measurement system installed at the Randa in-situ laboratory has been successfully tested. The sensors are able to measure micro-strain deformations. Finally, a specially designed fluorometer is installed at the Brigerbad thermal spring and is now continuously recording. With the gradual availability of the new instrumentation through the Global Sensor Network (GSN) middleware, the GIS Platform will be able to integrate and visualize real-time sensor data.

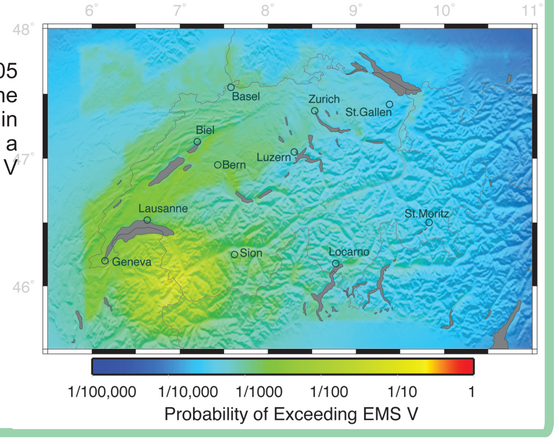
Instrumentation 2008-2010 (COGEAR, SSMNet, SwissTopo, SNF, SED, u.a.)



Seismotectonic Framework and Earthquake Weather

Models for the deformation and kinematics of the crust in the Valais are under development by combination of seismic and geodetic observations. Extensive analyses have been carried out on data from permanent GPS stations in Switzerland for deriving a regional deformation field. The relative linear movements are below 1 mm/year. A task related to time-dependent earthquake hazard assessment developed an automated tool for short-term earthquake forecast maps. They show the probability of exceeding in the next 24-hour period a ground motion intensity V. We are now evaluating to move these maps to a public web page. A network to observe short-term precursors is presently set up, including magneto-telluric and geo-chemical sensors.

Example:
After the September,8,2005 Vallorcine earthquake the probability of exceeding in the next 24-hour period a ground motion intensity V was increased.

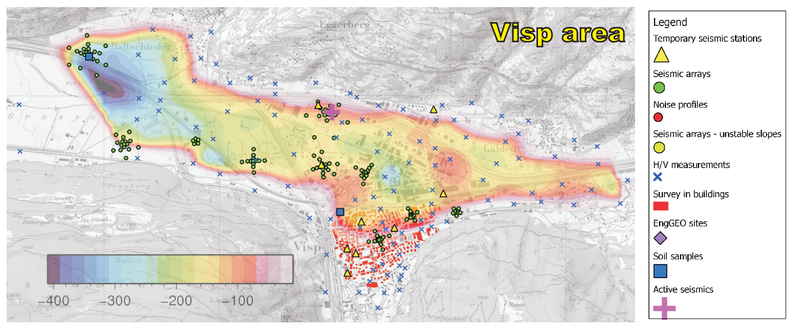


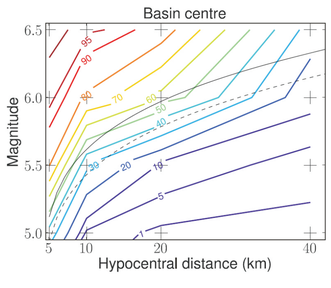
Strong Ground Motion and Building Response

Earthquake ground motion simulations using realistic finite earthquake source models and earth structure are presently set up. This includes a three-dimensional model for the project area. Relative site amplification at low strain within the Visp and Matter valley area was measured using recordings of small regional earthquakes acquired by a temporal seismic network. A model for nonlinear behavior of the sediments in Visp was developed based on laboratory measurements. The results indicate that soils may liquefy at rather low ground motion levels.

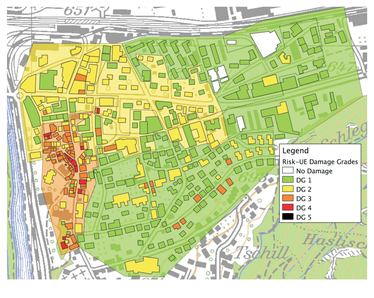
The impacts of a seismic event on the built environment were assessed through estimation of building vulnerability. This included the categorization of buildings in Visp. Existing empirical methods have been used, combined with a new approach based on in-situ ambient vibration recordings and numerical simulations.

COGEAR measurement program (2008-2010) and 3D velocity model of the area.





Probability for liquefaction in the Rhone plane at Visp in a given magnitude-distance range (Roten et al., 2009).



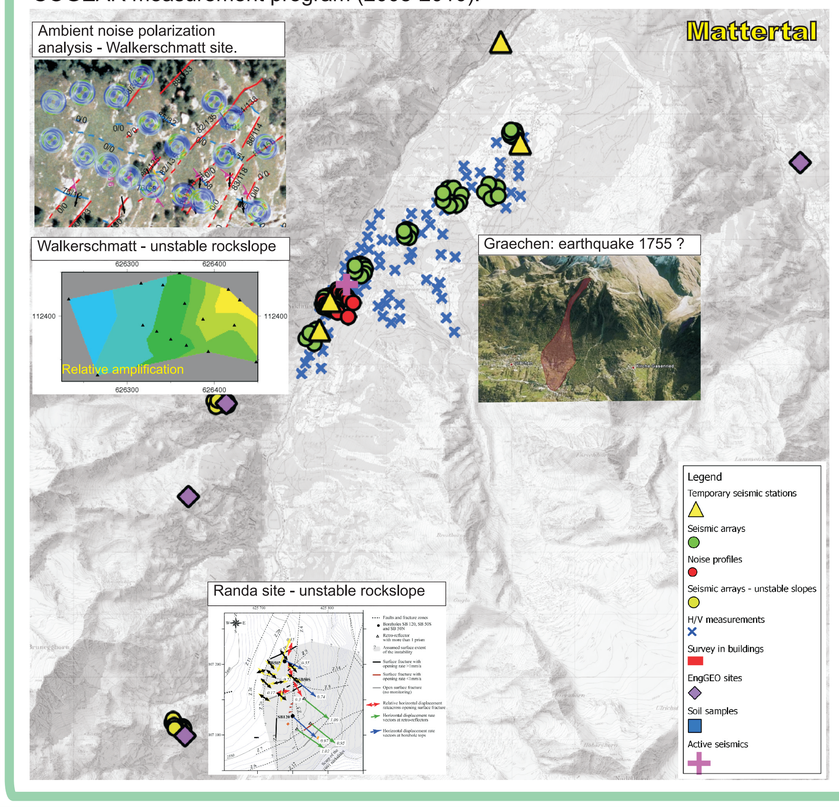
Building response in Visp - Intensity VIII
DG 3: substantial to heavy damage
DG 4: very heavy damage
DG 5: destruction

(Michel et al., 2010)

Triggered Landslides and Snow Avalanches

Ambient vibration measurements performed on unstable rock slopes in the Matter valley were found to be useful for rapidly obtaining spatial information regarding the internal structure. An observation of transient deformation induced by a local earthquake is in agreement with the fundamental frequencies of the unstable rock mass identified from ambient noise. An unstable rock slope above the village of Grächen was investigated which highlighted an interesting area of rock blocks that appear to move only during periods of strong ground shaking, and now show displacements on the order of one meter or more accumulated over the last ~20 thousand years. The study of snow avalanche triggering by earthquakes was initiated introducing a layered poro-elastic model of the snow-ground interface.

COGEAR measurement program (2008-2010).



Outlook. The COGEAR project started in February 2008 and is now in its third year. Scientific work is in progress and we expect new avenues as a result from this interdisciplinary context. The COGEAR GIS Platform is scheduled for launch in January 2011. During 2011, new live sensor data will be made available through the GIS platform, which will support the research in seismogenic hazards. The sensor network is continuously growing and we expect to have the full network running by the beginning of 2012.

References:

http://www.cces.ethz.ch/projects/hazri/COGEAR/publications

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