EGU General Assembly 2024

EGU24-14904, updated on 14 Aug 2024
https://doi.org/10.5194/egusphere-egu24-14904
EGU General Assembly 2024

High-resolution 3D seismic characterization of an Alpine slope instability using a 1'000 node array

Tjeerd Kiers[1], Cédric Schmelzbach[1], Hansruedi Maurer[1], Florian Amann[2], Pascal Edme[1], and Johan Robertsson[1]

[1]Institute of Geophysics, ETH Zurich, Zurich, Switzerland
[2]Engineering Geology and Hydrogeology, RWTH Aachen, Aachen, Germany

Slope instabilities, further destabilized by global warming and extreme weather conditions, pose increasing risks to life and property. Hence, understanding these potentially destructive phenomena is crucial to mitigate associated losses. Established approaches like remote sensing and radar-based observations yield important information on surface displacement. However, seismic imaging and monitoring techniques offer complementary insights into subsurface structures, physical properties and internal time-dependent processes that drive the slope instability evolution.

The ‘Cuolm da Vi’ slope near Sedrun in Central Switzerland is one of the largest mass movements in the Alps (100-200 million m^3) and is moving by up to 20cm/year. Even though it currently does not pose an immediate threat, the surface displacement of the slope instability is closely monitored. Yet, knowledge about its internal structure is limited such as, for example, the vertical extent of the unstable section which is suspected to reach several hundred meters in depth. The main objective of our project is to gain new insights into the slope instability structure and evolution. Furthermore, we aim to extend this towards innovative seismic strategies for the characterization and monitoring of large-scale mass movements in general.

In summer 2022, we deployed an extensive seismic sensor network at Cuolm da Vi covering an area of approximately 0.6 km^2. This network consisted of over 1'000 autonomous nodes arranged in a hexagonal grid pattern. In addition, we installed a 6-kilometer-long fiber-optic cable, targeted for long-term Distributed Acoustic Sensing (DAS) and Distributed Strain Sensing (DSS) measurements. This unique multi-sensor geophysical network enables us to investigate the unstable slope with an unprecedented level of spatial and temporal resolution, allowing us to monitor time-dependent changes over a broad spectrum of scales in space and time. During 2022 and 2023, we collected an extensive data set, including extended periods of continuous acquisition using the nodal, DAS, and DSS systems.

During the summer 2022 acquisition period, we conducted a controlled-source seismic experiment to characterize the 3D subsurface structure using seismic imaging techniques. Recordings of 163 dynamite shots by the 1’000 node array resulted in more than 30’000 P-wave first-arrival travel-time picks. Using 3D travel-time tomography, we established a first 3D subsurface P-wave velocity model of the Cuolm da Vi body. The resultant tomograms exhibit strong lateral and vertical velocity contrasts, which correlate at the surface with mapped tectonic features and identified instable sections. Furthermore, velocity anomalies within the slope instability volume indicate significant structural and/or geological variations in space. In combination with the other seismic and geotechnical information, the 3D seismic velocity model allows us to, for example, revise hazard scenarios.