ECGS & ESC/EAEE Joint Workshop: Earthquake and Induced Multi-Risk Early Warning and Rapid Response

Landslide induced seismicity: near real-time detection and characterization using regional seismic networks

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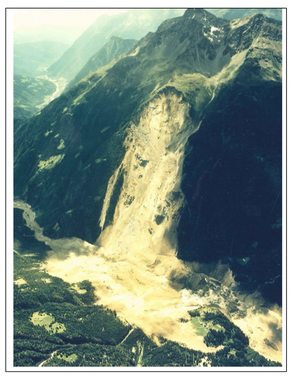
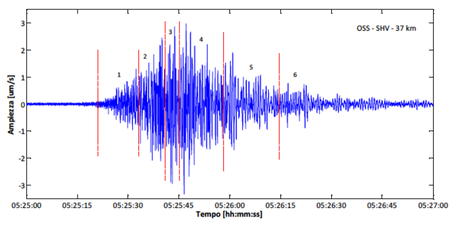
Landslides & broadband seismic networks

Val Pola landslide, 1987, Italy



Ground vibrations caused by landslide processes can be recorded by seismic networks at different scales (local, regional, global)



Dammeier et al., JGR 2011

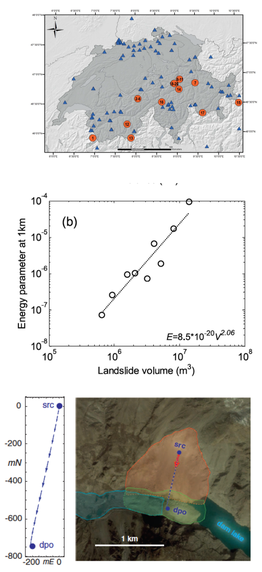
Back analysis of the Suisse seismic catalogue. Identification and characterization of landslides with simple metrics on the recorded seismic signal

Yamada et al., GRL 2012

Study of seismic waveforms caused by large landslides triggered by typhoons in Japan. Identification of relationships between seismic energy release and landslide volume

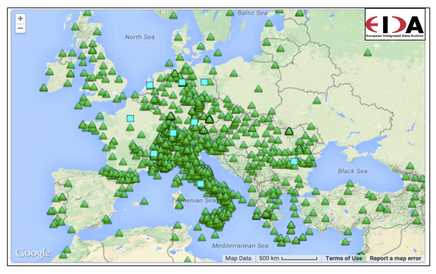
Ekstrom and Stark, Science 2013

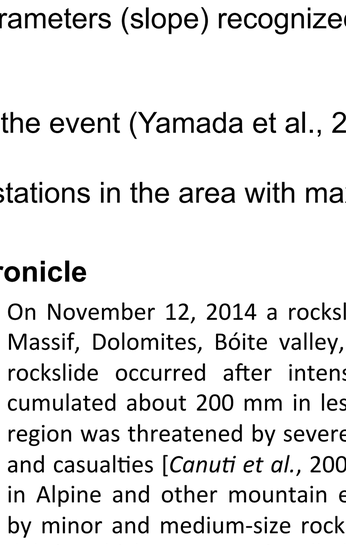
Analysis of teleseismic data (GSN) to detect and characterize large mass movements occurring in remote areas



Question: can we exploit broadband seismic data to attempt location and characterization of event landslides in near real time?

The EIDA seismic network

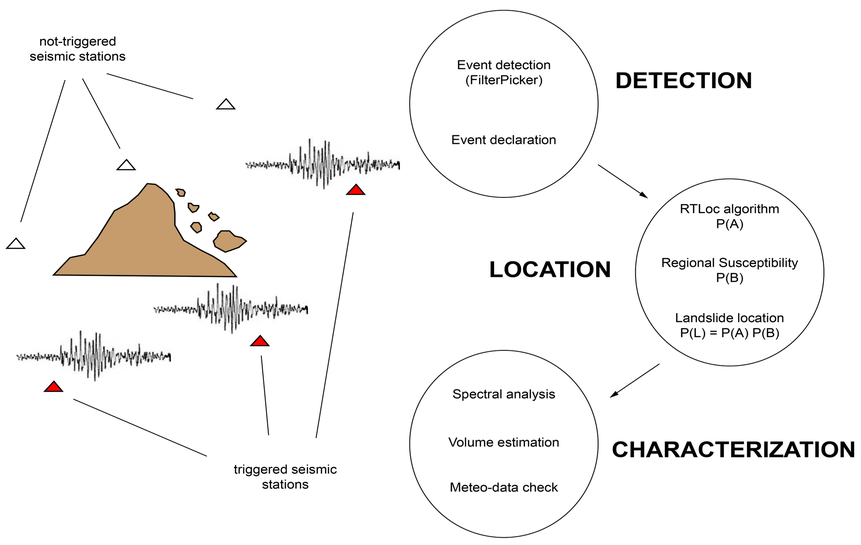




The Virtual European Broadband Seismograph Network (VEBSN) is rapidly expanding at a rate of about 70 BB stations per year, and also is creating a distributed, integrated European-scale data archive. VEBSN links a pool of open real-time BB stations (currently totaling more than 250) shared by contributing observatories and archived into a European Integrated Wave- form Data Archive (EIDA).

There is a good coverage of seismic stations over the zones with higher landslide susceptibility

Tested algorithm



1) Event detection: FilterPicker (Lomax et al., 2011) automatic picking of first arrivals to identify significant seismic events recorded by the monitoring network

2) Analysis of the spectral characteristics of the seismic signal (landslide energy released is generally in the 1-5 Hz range, e.g. Dammeier et al., 2011)

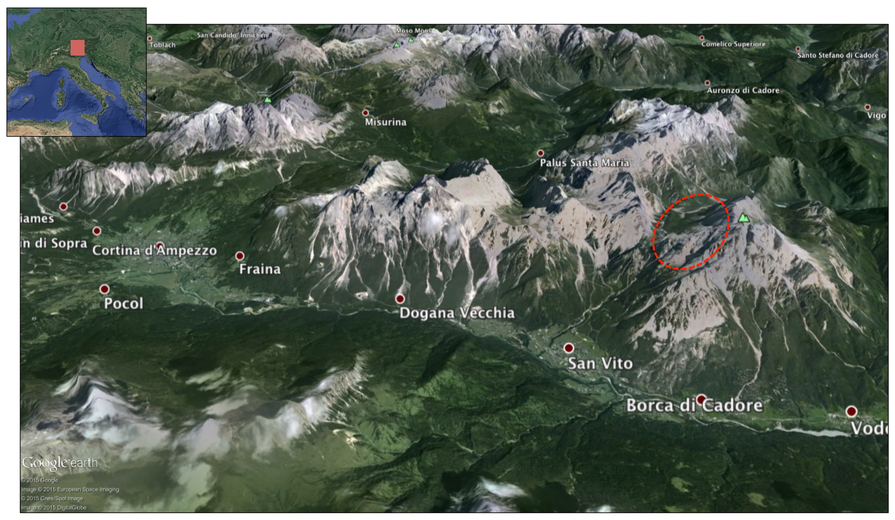
3) RTLoc approach (Satriano et al., 2008), PRESTo - PRobabilistic and Evolutionary early warning SysTem (Satriano et al., 2011)

4) Location probability is combined with morphometric parameters (slope) recognized as landslide predisposing factors

5) Computation of the approximate volume associated to the event (Yamada et al., 2012)

6) Check the available meteo-climatic parameters at the stations in the area with max location probability

The Antelao rockslide, November 12, 2014



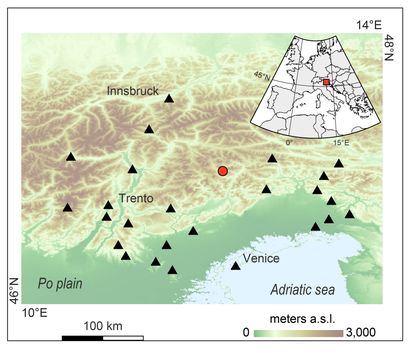
Chronicle

On November 12, 2014 a rockslide event occurred in the Antelao Massif, Dolomites, Bóite valley, eastern Italian Alps. The Antelao rockslide occurred after intense and continued rainfall, which cumulated about 200 mm in less than one week. In the past, this region was threatened by severe landslides, causing large damages and casualties [*Canuti et al.*, 2004]. Moreover, as frequently occurs in Alpine and other mountain environments, material dismantled by minor and medium-size rock falls progressively feeds basins of debris, which may occasionally be the source of devastating flows reaching the inhabited areas located downslope [*Bacchini and Zannoni*, 2003].

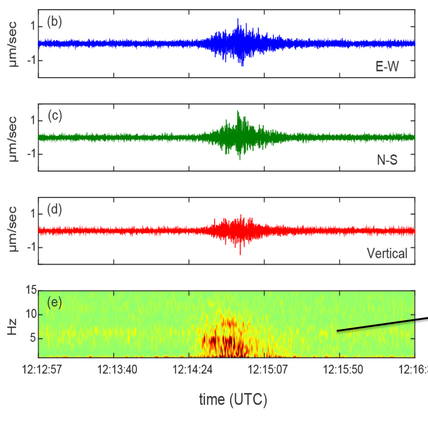
Local chronicles report that on 12 November, at around 12:00 (UTC), the population of hamlets located down valley and in the Alpine hut, "Rifugio Scotter" caught a distinct blast coming from the Antelao Massif. Field inspections were initially hindered by prohibitive meteorological conditions. Only several days later, aerial surveys permitted to identify the landslide source area (located at ca. 2,600 m a.s.l), the deposition zone (located at ca. 1,300 m a.s.l.), as well as to estimate the approximate volume of the mobilized material (between 1.0 and 1.5 x 10^5 m^3).

Approximated volume estimated from the aerial surveys: ca. 1x 10^5 m^3

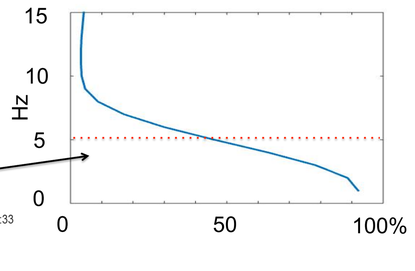
Several seismic stations of the INGV broadband network located nearby the area hit by the rockslide



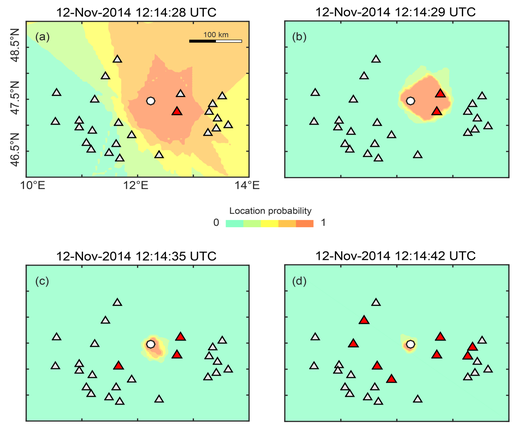
FVI stations, ca. 40 km away form the source



Spectrogram shows max. energy release below 5 Hz

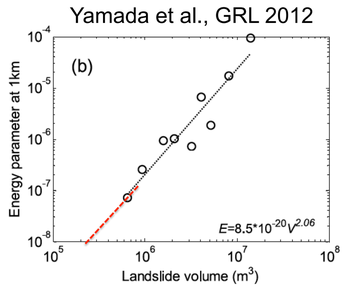


Location with RTLoc



Estimation of landslide volume

Yamada et al., GRL 2012



Energy paramater

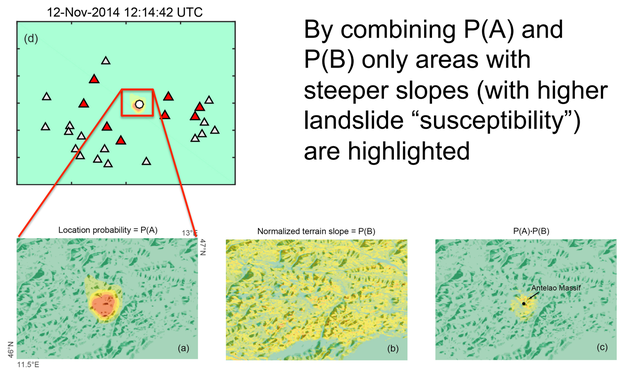
$$E = \sum_{t=t_0}^{t=t_1} v(t)^2 dt$$

v(t)= 1-4Hz band pass filtered velocity

Estimation of the energy paramater E for the Antelao rockslide leads to a value of **5x10^{-8}**

Fair agreement between landslide volume derived from seismic data and observations (1x10^5 m^3)

Location refinement: morphological constraints



By combining P(A) and P(B) only areas with steeper slopes (with higher landslide "susceptibility") are highlighted

Summary

- → We tested the feasibility of an algorithm to achieve near real time location and characterization of landside events by exploiting broadband seismic data
- → The algorihtm was applied to the recent Antelao Massif rockslide, achieving a good result in terms of location capability and also volume estimation
- → More tests on different case scenarios/landslide types to estimate the performance of the method are in progress

References

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