Seismo-acoustic analysis of Debris Flows events at the Illgraben catchment, Switzerland

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Debris flows are episodic strongly impacting gravitational currents of generally high density, consisting of mixtures of water and debris in varying proportions and occurring in steep mountain torrents with volumes commonly exceeding thousands of m\textsuperscript{3}. Despite the observation that debris flows are among the most dangerous processes in mountain environments, the moderate flow velocities (typically < 10 m/s) make early warning in principle possible if the flows are detected early upon formation.

Seismic and infrasound studies of debris flows rapidly increased in the last decade but focused mostly on event detectability and application as early-warning systems. Seismic networks, arrays of infrasound sensors and the combined use of a collocated single seismic and infrasound sensors, have turned out to be efficient systems for detecting the occurrence of debris flows in near-real time with a good reliability.

However, open questions remain about the possibility to infer source characteristics and event magnitude from recorded geophysical signals. This requires theoretical source models of elastic energy radiated both in the ground, in the form of seismic waves, and in the atmosphere, in the form of infrasound. Seismic waves are believed to be generated by both large sediment particles impacts on the channel bed and by turbulent structures within the debris flow. Infrasound is instead believed to be generated by standing waves at the free surface of the flow, but their source processes are not yet fully understood.

Here we present preliminary results of a study performed at the Illgraben catchment (Switzerland), in the 2017-2019 period, combining infrasound and seismic signals with direct in-torrent measurements of flow depth and velocity. Seismic and infrasound signals are analyzed using both spectral analysis and array techniques, in order to achieve an improved understanding of the dynamics of the source mechanisms of the two wavefields. Comparison with in-situ measurements is used to extrapolate empirical relationships between signal features, e.g. amplitude, spectral content or waveform characteristics of both seismic signals and infrasound, and flow characteristics.
The results obtained will possibly be used to develop an efficient monitoring system for remote detection and the early warning of debris flows using seismic signals and infrasound generated by the process.