EGU21-1226
https://doi.org/10.5194/egusphere-egu21-1226
EGU General Assembly 2021

Investigating infrasound sources within Illgraben debris-flows

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Debris flows are episodic gravitational currents, consisting of mixtures of water and debris in varying proportions. They occur in steep mountain torrents with volumes commonly exceeding thousands of m^3. Given their unpredictability and their capability to transport large boulders, debris flows rank among the most dangerous natural hazards in mountain environments. Nevertheless, moderate flow velocities (typically < 10 m/s) make early warning in principle possible if the flows are detected early upon formation.

Infrasound studies of debris flows increased significantly in the last decade, focusing mostly on event detectability and application for early-warning. The use of infrasound arrays and the combined use of collocated seismic and infrasound sensors have turned out to be efficient systems for reliable detection of debris flows in near-real time.

Despite these advances, open questions remain about the possibility to infer debris-flow source characteristics and event magnitude from recorded infrasonic signals. This requires theoretical and/or empirical source models describing elastic energy radiation in the atmosphere, in the form of infrasound, and relating it with fluid dynamic processes within a debris flow. Infrasound radiated by debris-flows is believed to be generated by standing waves that develop at the free surface of the flow, but details of the involved dynamic processes are not fully understood.

Here, we present the analysis of infrasonic signals recorded with a small aperture array during the 2017-2020 debris-flow seasons in the Illgraben catchment (Switzerland, Canton Valais), including more than 20 events of variable sizes. In order to better understand infrasound source mechanisms and to investigate the fluid dynamics processes involved in the infrasonic energy generation, debris-flow infrasound signals are quantitatively compared with independent hydraulic information of the flow (velocity, maximum flow depth and flow density). Finally, we discuss the use of extrapolated empirical relationships between infrasound signal features and flow characteristics for debris-flow monitoring and risk management.