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Research on debris flow early warning in the Gadria catchment (Eastern Italian Alps)

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Early Warning Systems (EWSs) for debris flows are receiving an increasing attention in the scientific community. In particular, the so-called event-EWSs or alarm systems are becoming more attractive due the continuous development of new, compact and low-cost distributed sensor networks. Their goal is to detect the occurrence of a flow event when the process is already in progress, in order to spread an alarm and to evacuate those vulnerable infrastructures that would not require long alert time, typically transportation routes. Their performances depends on their capability (i) to perform accurate and rapid measurements, (ii) to store and process in real time a continuous data-stream, and (iii) to automatically disseminate the alarm information. EWSs can be definitively more cost-effective than structural mitigation measures but their design, management and maintenance are complex tasks that also need a direct involvement of local authorities. In addition, numerous EWSs are operational worldwide but few of them are regularly followed up by researchers after their installation.
In this work we present the performance of an EWS specifically designed for both research and operational purposes, under testing in the Gadria basin (Eastern Italian Alps) since 2013. The employed warning algorithm is based on the Signal-To-Noise (SNR) ratio detected by a linear array of three geophones installed along the main channel and located right upstream to an artificial retention basin. Complementary data (rainfalls, flow stage measurements, videos) assure event characterization and alarm validation. A flashing light installed on the bank of the channel is activated by the EWS in case of event detection, providing a visual validation of the algorithm performances. During five monitored seasons, eight debris flows and several debris floods were documented. All debris flow events that occurred from 2013 to 2016 were successfully detected by the EWS (five true positives, zero false negatives) and four short-duration false positives were produced. False alarms were discarded introducing a directional criterion for the threshold triggering (SNR threshold exceeded progressively with time from upstream to downstream). During the last monitoring season, instrumental bias partially compromised data recordings, storage and the warning outcome. This highlights again the importance of follow-up and maintenance of EWSs.