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Effects of signal attenuation in natural media on interpretation of acoustic emissions in the context early warning systems

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Gravity driven instabilities in natural media such as rockfalls, landslides, snow avalanches or glacier break-offs represent a significant class of natural hazards. Reliable prediction of imminence of such events combined with timely evacuation remain a challenge because material failure is a non linear process involving inherent heterogeneities affecting the outcome. Nevertheless, such materials break gradually with the weakest parts breaking first, producing precursory "micro-cracks" and associated elastic waves traveling in the material. The monitoring of such acoustic/micro-seismic activity offers valuable information on the progression of damage and imminence of global failure.

The main challenge is that acoustic waves are strongly attenuated during their travel through natural media thereby introducing ambiguity in the interpretation of the magnitude (severity) or leading to loss of detection for faraway events. For example, a micro-crack event would be measured as a large event if occurring close to the sensor, and as a small event if far from the sensor (or may not be detected at all). A more complete picture of acoustic emissions or micro- seismic activity requires deployment of a dense network of sensors that enables localization of sources and thus the determination of initial energy released with each event. However, such networks are prohibitively costly difficult to analyze in real time over scales of interest. Is it possible to find a way to analyze directly in real time the measured micro-seismic activity to infer the slope mechanical status?

Following a qualitative description of the observation problem and the processes leading to attenuation, a quantitative analysis is performed using a numerical model based on the classical Fiber Bundle Model. Introducing a basic attenuation law in such simple models enables to directly compare un-attenuated and attenuated acoustic activity (and also avalanche size-frequency distribution) at any location. Taking advantage of both the geometry of the sensor network and the attenuation properties, it appears that co-detecting an event on more than one sensor provides sufficient information on the initial size of the event and on its location to assess the global stability of the slope.