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The use of mathematical models for early warning purpose against debris flow risk

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Debris flow events are very common in mountain environments and their number increased in the last twenty years, possibly due to increment in the frequency of extreme rainfall events triggering such phenomena. Most of debris flows are caused by runoff that entrains a large quantity of sediments, forming a solid-liquid wave, or by a landslide that liquefies. The formers, also called runoff generated debris flows, are the result of three different physical processes: i) production of abundant runoff at the feet of rocky walls after storms, ii) entrainment of large amounts of sediments by runoff, with iii) the formation of a solid-liquid current that propagates downstream until the stoppage, with consequent for deposition of the solid phase in less steeper areas. For these reasons, debris flows mathematical models have to account for rainfall-runoff production, sediment entrainment and solid-liquid routing. In general, debris flow phenomena are very dangerous because of their rapidity and large destructive power against any obstacle they come across during their propagation. Due to the sudden occurrence and the fast downstream routing, early warning of debris flows assumes a great relevance for any reliable defense approach. It could become a fundamental as adaptation strategy to face the increase in frequency of these phenomena, as well as, the difficulty in predicting correctly the locations of their occurrence.

In this contribution we propose two possible applications of mathematical models for to early warning: i) when a high intensity rainfall is provided by nowcasting; ii) by means of quantitative precipitation estimates based on radar observations or by rain gauge measurements in the upper part of the mountain basin where debris flow are triggered. In the first case a mathematical model is used to estimate the potential entrainable sediment volume to be compared with a threshold value for debris flow inception; in the second case the mathematical model output consists of the areas that can be potentially hit by the debris flow.

The prerequisites for of using mathematical models in association with early warning are the reliability and robustness of the model themselves. In other words, the adopted models have to be widely and successfully tested against field observations in a predictive way. In this contribution we present our experience in this sense, with specific attention to some monitored field sites located in the Italian Dolomites.