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The issues of current rainfall estimation techniques in mountain natural multi-hazard investigation

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Mountain hazards (e.g., landslides, debris flows, and floods) induced by rainfall are complex phenomena that require good knowledge of rainfall representation at different spatiotemporal scales. This study reveals rainfall estimation from gauges is rather unrepresentative over a large spatial area in mountain regions. As a result, the conventional practice of adopting the triggering threshold for hazard early warning purposes is insufficient. The main reason is because of the huge orographic influence on rainfall distribution. Modern rainfall estimation methods such as numerical weather prediction modelling and remote sensing utilising radar from the space or on land are able to provide spatially more representative rainfall information in mountain areas. But unlike rain gauges, they only indirectly provide rainfall measurements. Remote sensing suffers from many sources of errors such as weather conditions, attenuation and sampling methods, while numerical weather prediction models suffer from spatiotemporal and amplitude errors depending on the model physics, dynamics, and model configuration.
A case study based on Sichuan, China is used to illustrate the significant difference among the three aforementioned rainfall estimation methods. We argue none of those methods can be relied on individually, and the challenge is on how to make the full utilisation of the three methods conjunctively because each of them only provides partial information. We propose that a data fusion approach should be adopted based on the Bayesian inference method. However such an approach requires the uncertainty information from all those estimation techniques which still need extensive research. We hope this study will raise the awareness of this important issue and highlight the knowledge gap that should be filled in so that such a challenging problem could be tackled collectively by the community.