Geophysical Research Abstracts
Vol. 21, EGU2019-13598, 2019
EGU General Assembly 2019

Rainfall estimation uncertainty and early warning procedures for post-fire debris flows

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Early warning systems for rainfall-induced hazards rely generally on the estimation of rainfall from near real-time remote sensing (radar and satellite) or forecasts provided from numerical weather prediction (NWP) models, which are used as input to statistical or physics-based models for hazard prediction. Therefore, the effectiveness of hazard forecasting depends greatly on the accurate estimation of the magnitude and spatial-temporal distribution of the triggering rainfall. However, both sources of rainfall estimates are associated with uncertainty which propagates and interacts nonlinearly with the other components of the hazard forecasting system, thus resulting in uncertain predictions. Despite its importance, rainfall estimation uncertainty is usually not accounted for in the predictions provided by operational warning procedures. Therefore, quantification of rainfall estimation uncertainty and understanding of its propagation and impact on hazard prediction is a very important step towards advancing early warning systems of rainfall-induced hazards.

In this work, we present an investigation on the uncertainty in rainfall estimation and its propagation in hazard prediction for the case of the recent mudslides that occurred in Montecito, California during January 2018. We focus on the analysis of rainfall estimation uncertainty from radar and satellite remote sensors and an ensemble NWP system for quantifying the storm event that triggered the mudslides and evaluate the uncertainty in mudslide predictions based on the operational thresholds provided by the USGS post-fire debris flow hazard system. The MRMS radar dataset was used as the reference rainfall dataset to compare against the radar NCEP Stage IV, the satellite IMERG data and ensemble simulations from WRF model. Results demonstrate the strengths and limitations of the various rainfall sources and highlight the impact of rainfall uncertainty on the prediction of debris flow occurrence emphasizing on the value of accounting for rainfall uncertainty in final estimates of occurrence probabilities. Finally, we demonstrate that the blending of estimates from high-resolution NWP and satellite remote sensing can potentially provide an effective way for developing warning procedures over areas where ground observations are missing.