X-MP Radar for Debris Flow Debris Flow Hazard Estimation in Volcanic Area in Indonesia

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Debris flow, which is the most serious secondary impact of volcanic disaster, is highly induced by rainfall. Limited access to the area of active volcano slope as well as risk of measurement gages damage due to disaster motivate to the use of X-band weather radars for observing the rainfall. In 2015, X-band multiparameter compact radar (X-MP) radars were installed in Merapi Volcano and Kelud Volcanoes Indonesia. Compared with the number of available raingauges in the area, the radars have wider coverage with high resolution which is beneficial for detecting rain-causing debris flow in these areas. In this study, potential use of X-MP radar for debris flow hazard estimation is presented.

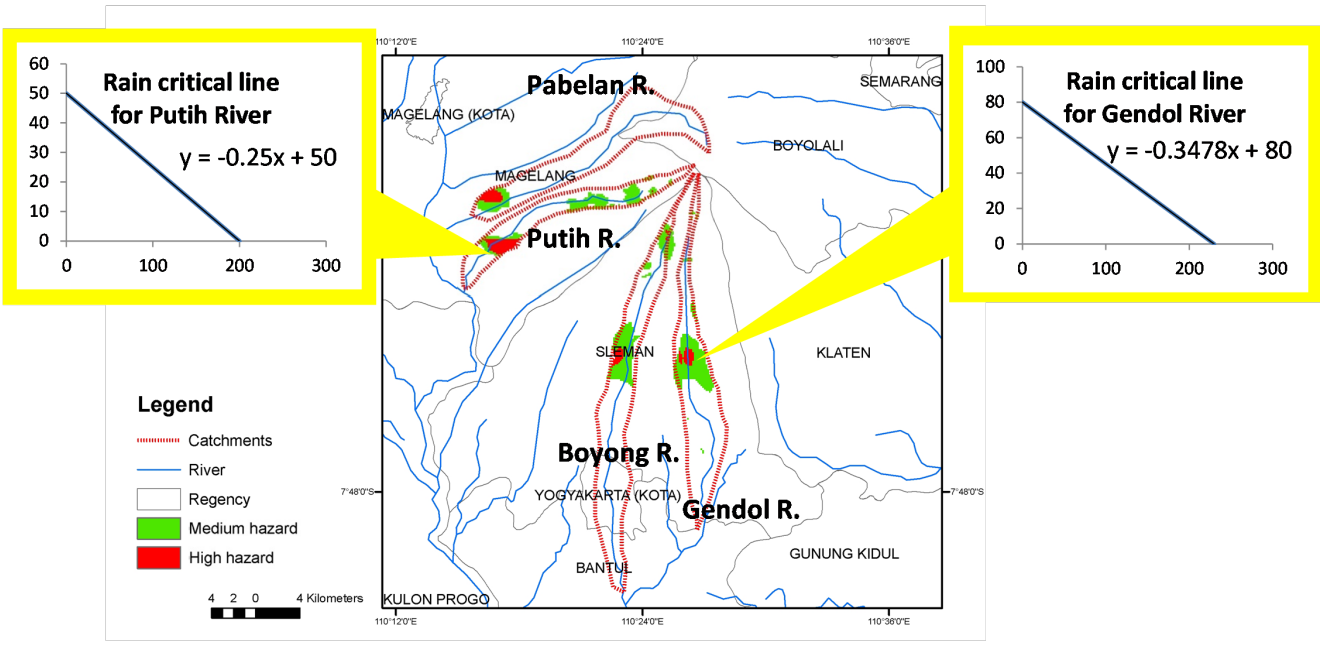
The rainfall critical line is developed from observed radar and debris data. and used to categorize the high and medium hazard level of rain-triggered debris flow. Debris hazard map is developed by evaluating the maximum rainfall and the working rainfall obtained from X-MP radar nowcasting product in grid mesh units. By using this map, the vulnerable river to debris flow can be predicted in real-time scheme.

The use of radar-rain prediction in sediment-related disaster involves high amount of uncertainties. Therefore, it is necessary to assess the uncertainties of debris flow hazard estimation. The ensemble rain prediction by perturbing the advection vector is introduced. The benefits of ensemble forecasting over the single deterministic forecast are demonstrated, particularly to reduce missing of severe events. By evaluating five ensemble rainfall spatial distributions at once, the basin or village that is most likely to be hit by the debris flow is analyzed through hazard zoning. In order to evaluate the uncertainty of predicted rainfall temporal variation, snake lines development of hourly and working rainfall from radar ensemble nowcasting products is drawn against the critical lines.

It is believed that information of past rainfall is important to estimate the likelihood of the debris occurrence. The predictability of debris disaster warning system by applying Naïve Bayes Classifier (NBC) is assessed. In addition to rainfall measurement, topography and soil type parameters are included as predictors. Prior and conditional probabilities of debris occurrences are estimated using the training data to obtain the estimates of the posterior probabilities. The system verification is performed by quantitative dichotomous quality indices along with contingency table.

With three years available data of X-MP radar, these systems could help mitigating lahar disaster in volcanic rivers. Using the validation datasets, it can be concluded that the integration of ensemble forecast product could provide a plausible range of the prediction possibility. NBC approach with longer training dataset could improve the prediction capability. Regardless the existence of predictive uncertainty sourced from the rainfall forecasting model, the presented system could contribute to improve the debris flow countermeasure in volcanic regions.

Keywords: Debris, X-band polarimetric radar, Rainfall


Rain critical line
for Putih River
y = -0.25x + 50
60
50
40
30
20
10
0
0
100
200
300
Rain critical line
for Gendol River
y = -0.3478x + 80
100
80
60
40
20
0
0
100
200
300
110°12'0"E
110°24'0"E
110°36'0"E
7°48'0"S
Pabelan R.
Putih R.
Boyong R.
Gendol R.
MAGELANG (KOTA)
MAGELANG
SEMARANG
BOYOLALI
SLEMAN
KLATEN
YOGYAKARTA (KOTA)
BANTUL
GUNUNG KIDUL
KULON PROGO
Legend
Catchments
River
Regency
Medium hazard
High hazard
4 2 0 4 Kilometers