Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

HDS06-P06 Room:Convention Hall Time:May 27 18:15-19:30

XMP Radar application to optimize volcanic debris flow measurement in Merapi volcano

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Merapi is one of the world's most active volcano that is well known for its disastrous volcanic debris flow (*lahars*). Previously it has been understood that lahars at Merapi were triggered by rainfall with minimum intensity about 40 mm in 2 hour. However after its 2010 centennial eruption that deposited 10 times volume of pyroclastic materials of 1994 and 2006 eruptions, lahars at Merapi experiences different behavior as it is easily triggered by lower rainfall intensity at 14 mm in 1 hour and were also reported occurred in some areas that had never experienced lahars flow within 40 years. Since it is triggered by lower rainfall intensity now, it has been observed that lahars in Merapi occurred not only during rainy season but also in dry season.

Rainfall intensity in Merapi volcano plays important role not only on triggering and migrating sediment but also determining the level of damages. When rainfall intensity exceeds its threshold, the onset of generated lahars would happen within few hours. For Merapi volcano, it was suggested that rainfall intensity should be monitored for at least every 30 minutes duration. Variation of Merapi topography should also be considered when observing rainfall characteristic, since rainfall is also influenced by this small scaled climate factor. Hence using single raingauge is not recommended due to difficulties of installation, distribution and maintenance. Using raingauge would give limited spatial and temporal resolution.

A Radar system offers a way of measuring areal precipitation with both high spatial and temporal resolution and therefore currently offer the best solution to measure rainfall spatial variability in catchment area. The spatial resolution offered by ground based radar systems can range from ten of meter up to a kilometer, whereas the temporal resolution can range from seconds to an hour. This is an important factors for lahars measurement because in Merapi lahars generated at higher elevations and become more hazardous at 450-600 m elevation in each of the 13 rivers which drain the volcano.

X band dual polarimetric (XMP) radar has been installed at 110.4 E; -7.6 S or 14.3 km from Merapi's summit, Yogyakarta Regency, Indonesia. It has 6 s temporal resolution whereas spatial resolution ranging at 50-250 m mesh. This XMP radar has 9 GHz frecuency and 3.33 cm wavelength which gives far greater resolution than what can be achieved by raingauge network or typical operational C Band radar. Two rivers, Kali Boyong and Kali Gendol that mainly experience lahars every year were chosen to be observed. Both are still in range of 30 km radius of radar detection and flow in dense populated area.

Research objective is to estimate lahars in Kali Gendol and Kali Boyong using improved hyperKANAKO model. Hyper-KANAKO model is graphical user interface system that is able to predict 2 dimensional debris flow with considering sabo dams planning to reduce loss due to lahars occurrence. This system requires upstream hydrograph, landform information and sabo dam conditions to simulate flow depth, river bed variation, flow discharge and sediment discharge.

Landform information would be gained using geographic information system whereas sabo dam information would be collected based on secondary data. There are 56 and 22 sabo dams respectively at kali Boyong and kali Gendol. Mathematical model between rainfall intensity from XMP radar and discharge data would be used to modify upstream hydrograph. Thus hyperKANAKO model in this research would directly use rainfall information derived from XMP-radar. Output of hyperKANAKO model is expected to not only give information about lahars deposits but also on better management of sabo dam construction

Keywords: Merapi, Lahars, Hyperkanako model, XMP radar