Quantitative detection of debris flow by using tilt and strain meters

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Instruments for volcano monitoring are available to detect debris flow at Sakurajima where vulcanian eruptions and debris flow frequently have occurred since 2009. Seismic observation is conventional method to detect debris flows as shown by high-frequency tremor-like waves. However, seismic waves are insufficient to estimate volume of debris flow. Here, I will propose a method to estimate volume of debris flow by using ground deformation associated with debris flows.
Upward tilts of the crater side of Sakurajima have been detected 5 min to 1 day before volcanic eruptions. Upward tilts of the crater side were also detected at the same site associated with debris flows streaming in Arimura river, opposite side of the crater in the view of the tiltmeter, because deposits of debris flows induce downward tilt of the river side. On the other hand, radial strain shows different change patterns between precursory inflation of eruptions and debris flows. Radial strain shows contraction prior to eruptions, but extension of radial strain is recorded associated with debris flows. Such deformations are detected for 65 debris flows in the Arimura river except for 4 minor flows during the period from 2009 to 2016. Amounts of tilt changes ranged from 4 to 409 nano radian. The downward tilt vectors are oriented to the no.1 Sabo dam and it is inferred that the deformation is caused by deposit of debris flow at the Sabo dam. Extension changes of radial strains ranged from 3 to 138 nano strain and are almost 1/3 of the tilt changes. Assuming a point mass applied to the river surface, increase of weight on the river is estimated to 60 thousands ton in case of strain change of 30 nano. Total weight of debris flows is estimated to be 2 million tons during the period from 2009 to 2016.

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