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# The influence of increasing rainfall due to climate change on landslide slopes

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1. Objective
Increase in rainfall that supposed to be induced by the global climate change is obvious in western Japan, according to the analysis of rainfall data observed in various locations including mountainside that are not influenced by local warming due to urbanization. On this point of view, we elucidated the response of landslide slope to this increase in rainfall. Hence, its long term influence on the specific landslide slopes in this area was analyzed using numerical simulation method i.e. finite element method in order to evaluate the landslide slope stability.

2. Method and target areas
Field investigation on landslides slopes and slope failures was conducted to obtain the geologic information, geo-structure, vegetation feature, soil samples and topographic data i.e. cross sections. Accordingly soil shear tests and soil permeability tests are also conducted. The rainfall data at the nearest rain observatory were obtained from the database of Japan meteorological agency. The long term impact on the slope stability in the area is analyzed by the finite element method (FEM) combined with rain infiltration and seepage analysis with the long term rainfall fluctuation data, obtaining factor of safety (Fs) on real landslide slopes.
The target areas are located in northern Kyushu district, western Japan where they are often suffered from severe landslide disasters. For the FEM analysis, eight landslide slopes are selected from ones that occurred due to heavy rainfall caused by stationary front in July 2009∼2017. The geology in research areas consists of Paleozoic and Mesozoic rocks (mainly schist, slate, and serpentine) and volcanic sediment. The vegetation consists of mainly Japanese cypress, cedar or bamboo.

3. Result and consideration
Consequently, the long term rainfall increase in the region such as increment of approximately 20∼25mm/hr for rain intensity (Ri), or 50∼85mm/day for daily rainfall (Rd) in 40 years is confirmed statistically using Kendall's rank correlation, and it is found that its impact on slope stability is obvious and critical. In the sample landslide slopes, even the increase in rain of duration for only 10 years has severe impact on their stabilities in terms of Fs. The Fs calculated with assumption of no rainfall increase for this decade is higher than 1.0 such as 1.05. This corresponds to stable state which means 5% or more stable state, whereas, the Fs with present rainfalls is lower than 1.0 such as 0.98 (in this study, maxumum 30% reduction in stability was found).

4. Conclusion
The increase of rainfall Ri, Rd due to climate change with the increasing rate such as 24mm/hr or 83mm/day in 40 years surely has strong impact on almost landslide slopes in aspects of slope stability. Therefore, with this rainfall increase rate, it is possible for many forest slopes or natural slopes to become unstable and cause landslide disasters.