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Characterization of Snake Lines and Insights into Sediment Hazards in a Changing Climate

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Background

Recently the impact of climate change on sediment disasters has drawn higher attention in the public. To better estimate the future risk of sediment disasters in a changing climate is currently one of essential issues for pursuing a safer and more sustainable living environment of the human society. To this end, we aim to quantitatively investigate the future change of hazardous rainfall prone to landslides and sediment disasters. As being applying for the current practice of early warning of sediment disaster, the well-calibrated critical line method is the proxy tool in this study. The critical line method utilizes two hydrometeorological parameters, i.e., hourly rainfall and soil-water index, to represent the conditions of soil moisture during any given rainfall event. A curve composing of the two parameters is called a snake line which can present the vulnerability of sediment or water-related hazards. Wu et al. (2021) have reported the future change of snake line patterns by separately considering the maxima of the two parameters (see Fig. 1a) with a focus on extreme conditions. However, situations for common rainfall events were not considered, and the relation between the two parameters and its future changes are still lacking of explanation. Hence, the study would like to statistically examine the change pattern and relation between two parameters of snake lines using future climate projections.

Data and methods

The Non-hydrostatic Regional Climate Models in the resolutions of 2 and 5 km (abbreviated as RCM5 and RCM2), published by Meteorological Research Institute Japan Meteorological Agency, are used in this study. Both of the scenarios of RCP8.5 and RCP2.6 are considered. For our objective, only the variable of surface precipitation of liquid water in the full data periods is straightforwardly extracted at each 1-km mesh in the 3rd coordinate system published by MLIT without any interpolation. On each mesh, to present each given rainfall event, the pair of maximum hourly rainfall and soil-water index is derived from the two RCMs with a threshold of minimum hourly rainfall of 1 mm. Then, the two distributions consisting of all pairs (see an example in Fig. 1b) from the present and future datasets are testified by the Hotelling's t^2-test. Changes of confidence ellipses are also examined.

Current and expected results

According to the extension and/or shrink of the confidence ellipses between the present and future datasets, six types of snake line patterns are used for explaining the future change of common situations of snake line patterns. With the significance level of 0.05, the spatial distributions and area ratios of each stretch type are shown in Fig. 2. From both RCMs, only 10% of meshes have slight extension of snake line pattern under the RCP2.6 scenario, and less than 5% with higher or concentrated hourly rainfall in east Japan. Oppositely, under RCP8.5, there are more than 80% of meshes exhibiting the obvious extension of snake line pattern (Types A to C), but around 3% with shrink pattern (Type E) particularly in Kii peninsula and east Shikoku region. More analysis will be conducted on comprehensively exploring snake line patterns and sediment disasters in a changing climate.

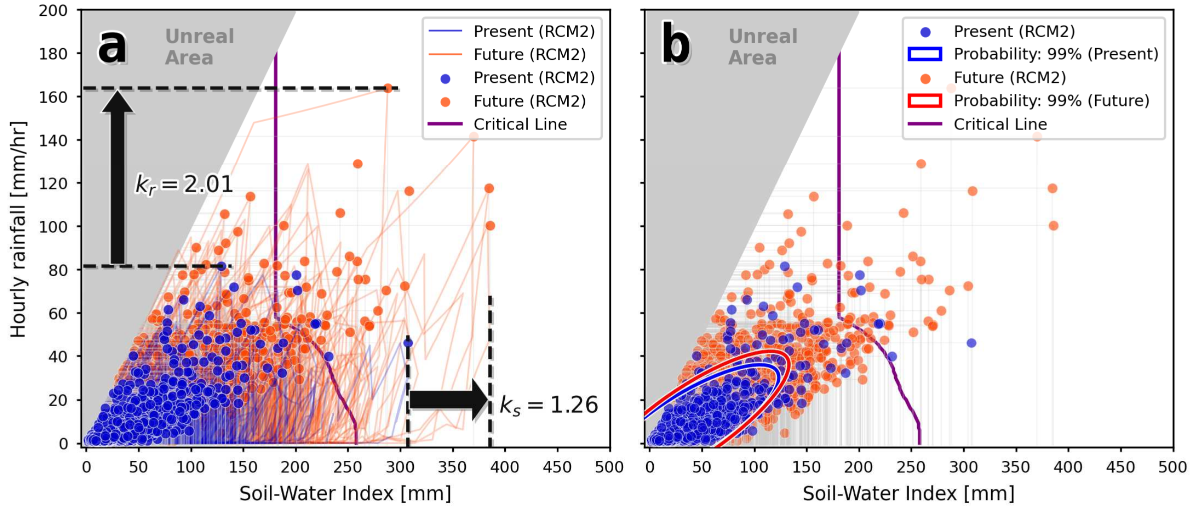

Fig. 1 Definition of the future change of analysis targets. Take an example of all rainfall events from RCM2 and corresponding snake lines on the Mesh #50300668 in Asakura, Fukuoka. a) Extreme change ratios of maximum hourly rainfall and soil-water index; b) Distribution of the pairs of maximum soil-water index and hourly rainfall from all rainfall events with confidence ellipses of the significance level of 0.01.

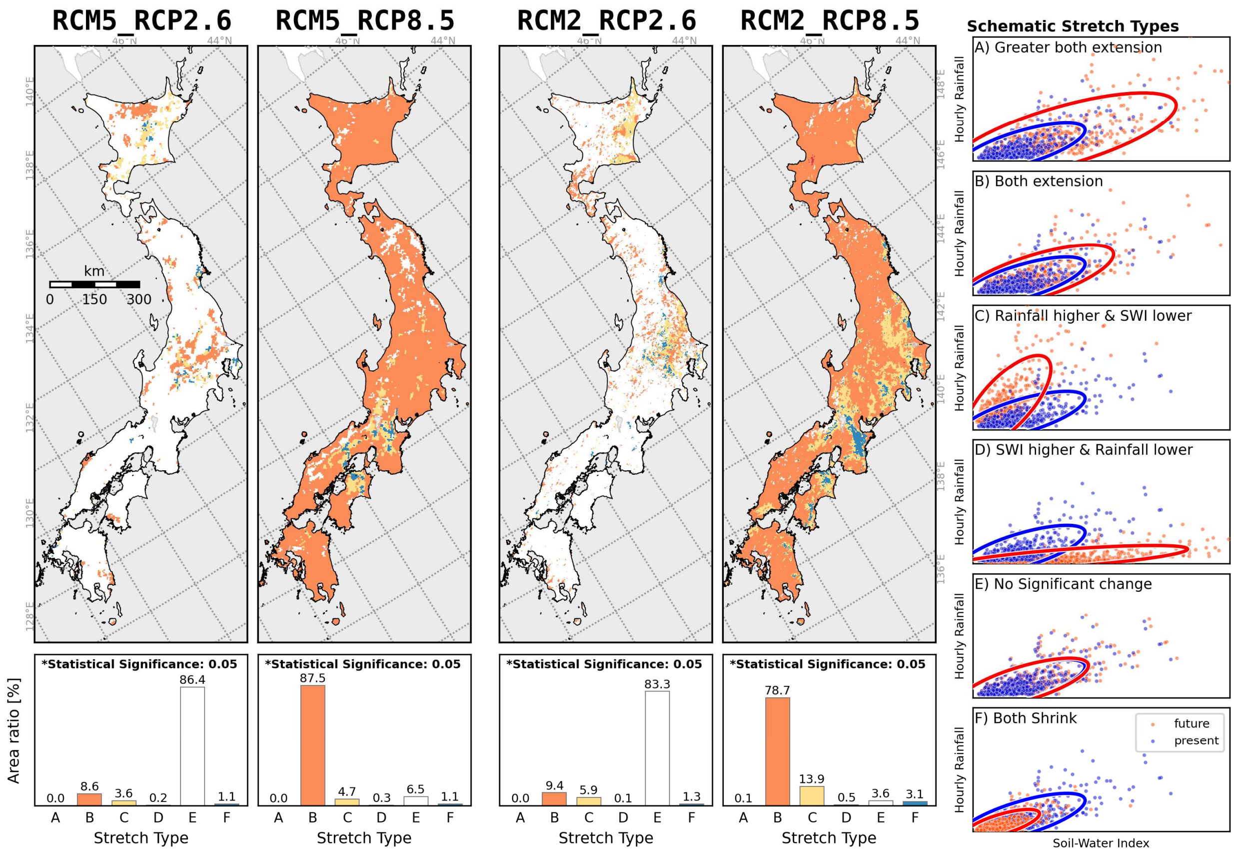

Fig. 2 Future change of snake line distribution on each mesh under scenarios of RCP2.6 and RCP8.5 from the datasets of RCM5 and RCM2 with statistically significant level of 0.05. Six patterns are considered. Particularly, Type A denotes the extension of 20% greater than the confidence ellipse of present climate.

Acknowledgement

This research is supported by the “Integrated Research Program for Advancing Climate Models (TOUGOU program)” from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan. The authors would like to appreciate MLIT Sabo Office and prefectural governments for providing valuable critical line information.

References

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