Study on a Technique for Analysis of the Spatiotemporal Distribution of Rainfall in Flood Control Planning Based on Climate Change

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1. Introduction

Based on concern that increased rainfall due to the effects of climate change may cause increase of rainfall and intensification of flood damage, NILIM calculated the ratio of rainfall under the present climate and future climate (hereinafter, the rate of change in heavy rainfall intensity [1]) using ensemble climate prediction data as 1.1 (1.15 in Hokkaido) at a 2 °C temperature rise. This value was used in the revision of the MLIT's Basic River Management Policy.

The rate of change in heavy rainfall intensity is an index that focuses on the total amount of rainfall in 1 rainfall event. However, even if the total amount of rainfall is approximately the same, there is concern that it may cause larger flooding damage in large rivers, along tributaries and in downstream flood plain areas, depending on the spatiotemporal distribution of the rainfall in cases such as concentrated rain in a short period or local concentrated rain. Moreover, because the spatiotemporal distribution of rainfall experienced in the past will not necessarily be the same in the future climate, work to compare the actual rainfall data from the past and the ensemble climate prediction data and confirm various spatiotemporal distributions of rainfall was carried out in the above-mentioned revision of the Basic River Management Policy. Nevertheless, analysis of the enormous volume of rainfall data in terms of the three dimensions of temporal changes, spatial changes and changes in total rainfall has resulted in an increased degree of difficulty in the work of studying flood control planning in the Basic River Management Policy, etc. In addition, from the viewpoint of river basin flood control, disaster prevention urban planning, etc., including measures to prevent outflow from rice field dams, etc. and land use, is being studied for a range of rainfall events from high frequency to low frequency, but in this, it is important to understand the future changes in the spatiotemporal distribution in the entire basin, and not simply in rivers.

Against this backdrop, in this research, pattern classification by self-organizing maps was carried out using the ensemble climate prediction data [2] (**Table-1**) in order to grasp the future changes in the spatiotemporal distribution of rainfall.

Table-1 Ensemble climate prediction database

Data name	Yesrs	No. of members	Sea surface water temp.	Time resolution	Space resolution
Past experiment	31 years	12	1 pattern	1 hr	5 km
2 °C temp. rise experiment	31 years	2	6 pattern	1 hr	5 km

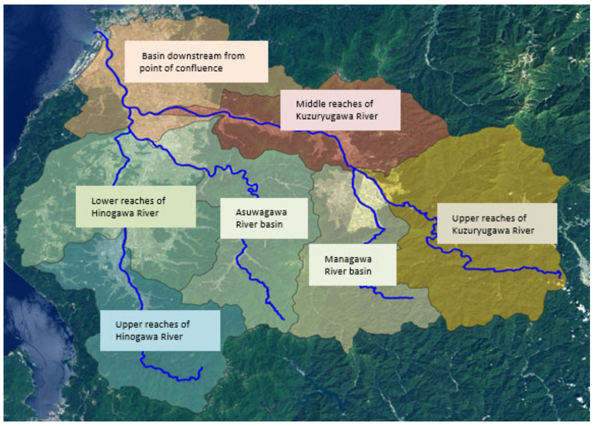
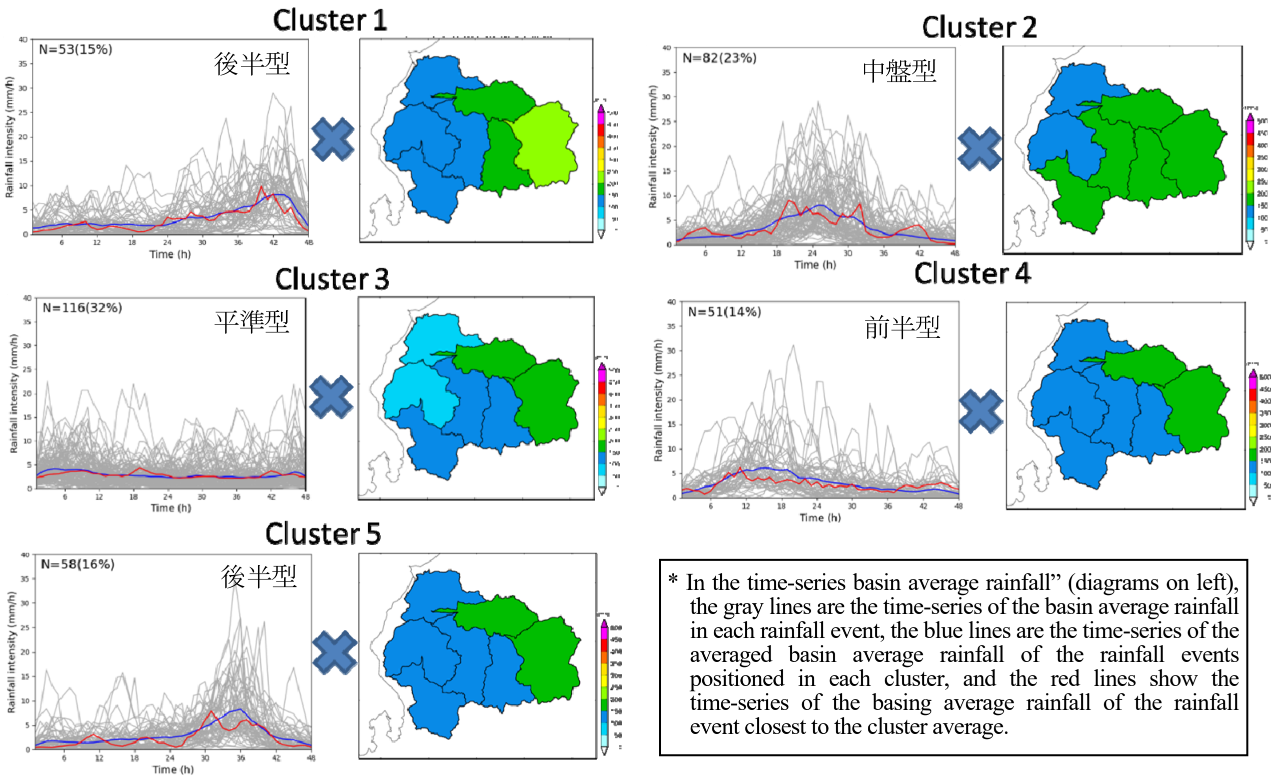


Fig.-1 Kuzuryu River Basin

2. Pattern Classification by Self-Organized Map

Self-organized maps are one type of machine learning which has many examples of use as a classification method for weather patterns and can map high-dimensional data on low-dimensional space. In this research, we extracted rainfall events that cause the annual maximum basin average rainfall for the present climate and future climate, and visualized and classified the spatiotemporal distribution (3-dimensional data of time x space x amount of rainfall) of each of the rainfall events on a 2-dimensional space.

The target was the Kuzuryu River basin shown in **Fig.-1**. The results of pattern classification of the spatiotemporal distribution of rainfall in the present climate are shown in **Fig.-2**. **Fig.-2** shows the "time-series diagrams of the average rainfall in the basin" (left) as diagrams showing the temporal distribution of the rainfall events, and "average value diagrams of the cumulative rainfall for each middle reaches of the basin"



* In the time-series basin average rainfall" (diagrams on left), the gray lines are the time-series of the basin average rainfall in each rainfall event, the blue lines are the time-series of the averaged basin average rainfall of the rainfall events positioned in each cluster, and the red lines show the time-series of the basing average rainfall of the rainfall event closest to the cluster average.

Fig.-2 Results of pattern classification of the spatiotemporal distribution of rainfall (present climate)

Table-2 Rainfall patterns of each cluster, number of rainfall events, and percentage of the total (present climate)

Cluster	Rainfall pattern (temporal direction x spatial direction)	No.	%
1	Later period x Main river upstream	53	15%
2	Middle period x Main river/tributary upper reaches	82	23%
3	Level x Main river middle reaches	116	32%
4	Early period x Main river/middle reaches	51	14%
5	Later period x Main river/middle reaches	58	16%

Table-3 Rainfall patterns of each cluster, number of rainfall events, and percentage of the total (future climate)

Cluster	Rainfall pattern (temporal direction x spatial direction)	No.	%
1	Later period x Main river upstream	106	29%
2	Middle period x Main river/tributary upper reaches	86	24%
3	Level x Main river middle reaches	89	25%
4	Middle period x Main river upper reaches	79	22%

(right) as diagrams show the spatial distribution of the rainfall events. However, it can be understood that the rainfall events have been classified into 5 patterns with similar temporal or spatial ch aracteristics.

Table-2 and **Table-3** show the results when percentage in the total of the rainfall patterns, number of rainfall events and percentage in total under the present and future climates were arranged in each cluster. Looking at these two tables, it was found that the rainfall pattern of the "latter period type x river upstream type" (Cluster 1), in which a large amount of rain falls in the Kuzuryu River Basin in the latter part of rainfall events, shows an increasing tendency from the present climate to the future climate.

3. Conclusion

In the future, we plan to analyze the spatiotemporal distribution of rainfall of other river systems with different basin characteristics by the technique described here as part of a study of possibility of applying this technique and methods for improvement.

☞For more information:

1) TECHNICAL NOTE of the National Institute for Land and Infrastructure Management No. 1205, Technical Note on the Rate of Change in Heavy Rainfall Intensity for Flood Control Planning to Cope with Climate Change
https://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn1205.htm
2) Social Implementation of Climate Change Adaptation Technology Program (SI-CAT)
https://www.restec.or.jp/si-cat/_public/202003b/SI-CAT%20DDS5TK%E6%A6%82%E8%A6%81_200228.pdf