TA-123L

FUTURE CHANGES OF FLOOD CONTROL EFFECTS OF DAMS IN CLASS-A RIVERS IN JAPAN USING d4PDF

Keiichiro Kitaguchi*, Tomohiro Tanaka, Yasuto Tachikawa, Yutaka Ichikawa , Kim Summin and Kazuaki Yorozu

1.Objective

In order to discuss the effectiveness of existing dams against severer flood disasters in a changing climate, it is necessary to evaluate the effects that existing dams may have under the future climate and regional trends. In this study, we analyzed the effect of dams on the control of peak flood flows at downstream reference stations by using the rainfall-runoff model over class-A river basins of Japan and bias-corrected d4PDF annual maximum rainfall data developed by Kobayashi et al. [1].

2.Methods

2.1 Bias correction for large-scale ensemble climate prediction database “d4PDF”

Kobayashi et al. [1] corrected the bias of the annual maximum basin-averaged rainfall in the past climate simulation of a regional climate experiment of database for Policy Decision making for Future climate change (d4PDF). In this study, this rainfall data was used.

2.2 Overview of the target basin and rainfall-runoff model

In this study, we used the distributed rainfall-runoff model 1K-DHM [2] developed by Kobayashi et al. [1] in order to calculate the discharge. Dams which are developed in the runoff model have a catchment area of more than 5% of the basin area. A constant-volume discharge system was assumed for each dam.

2.3 Evaluation index for flood control effects of dams

To evaluate the impacts of climate change on the flood control effects of dams, the following indicators are used: 1) the rate of flood peak discharge at the reference station simulated with the model with/without the dam operation scheme (Hereinafter referred to as peak flow ratio.) and 2) equivalent rainfall to dam storage.

The peak flow ratio is calculated by dividing the maximum annual peak flow considering the dam operation by Kobayashi et al [1] into the maximum annual peak flow of a model assuming no dams exist in the basin. This flow is obtained from rainfall-runoff calculations without the dam model, assuming there is no dam in the basin. The closer the value of the peak flow rate ratio is to 1, the less the difference between the peak flow rates with and without the dam is, and the less the flood control effect is considered to be expressed. The equivalent rainfall to dam storage was obtained by dividing the effective flood control capacity of the dam by the catchment area. In the case of multiple dams in the system, the sum of the equivalent rainfall of each dam divided by the average of the catchment areas of each dam is used.

3.Results

3.1 Relationship between peak flow ratio and flood control effect of dams

The peak flow rate ratios were calculated for all cases of annual maximum rainfall in the past experiments and the 4-degree rise experiments and plotted against the flood peak discharge with the model without the dam operation schemes. The results for the Kitakami River basin, as an example, are shown in Figure 1. The larger the flood size and the larger the difference between the inflow rate of each dam in the basin and the starting flow rate of flood control, the smaller the peak flow ratio becomes and the more effective the flood control becomes. As a result, the graph of the peak flow ratio is a convex curve with a clear minimum value. Comparing the past experiment (blue line) and the 4-degree rise experiment (red line), the storage is used up before the peak time and the effect of dams are lost in a shorter return period on the 4-degree rise experiment. On the other hand, there are some basins that continue to exhibit flood control effects, with no clear minimum value even for the largest floods in the 4-degree rise experiment.

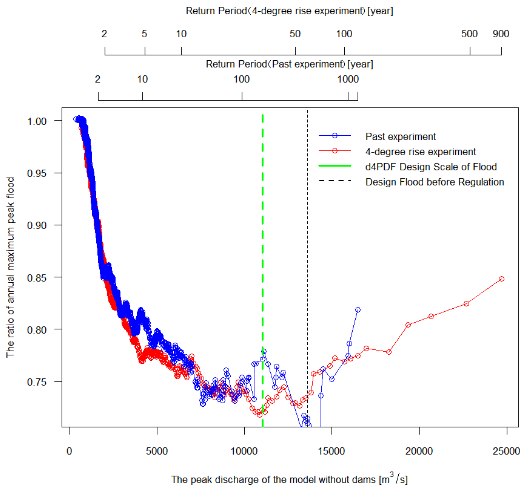

Figure 1 The relationship between the peak flow ratio and the peak discharge of the model without dams

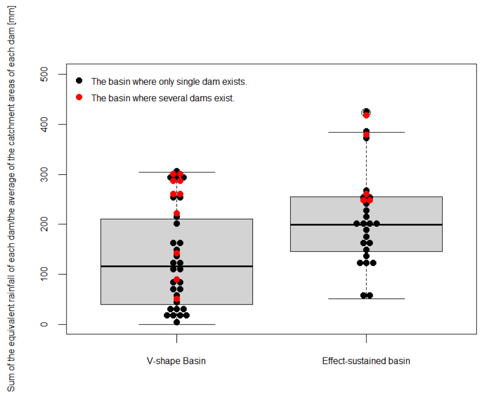

Figure2 Equivalent rainfall to dam storage of V-shape basins and effect-sustained basin.

The presence or absence of an inflection point on the peak flow ratio graph was visually determined for all basins. The basin with a clear minimum value was classified as a V-shape basin, and the basin without a clear minimum value was classified as a effect-sustained basin. The equivalent rainfall to dam storage of the V-shaped basins and the effect-sustained basins were calculated and compared (Figure 2). There is a clear difference in the equivalent rainfall.
The two-sample Kolmogorov-Smirnov test showed that the distributions were significantly different at the 1% level of significance. The results show that the flood control effect of dams is strongly related to the total equivalent rainfall of dams in the system. In addition, Figure 2 shows that in both types of water systems, the water system whose equivalent rainfall is located above the box whiskers often has multiple dams. This indicates that the flood control effect of dams is not greatly affected by the number of dams in a basin even in the 4- degree warmer climate.

Reference

1.Keita Kobayashi, Tomohiro Tanaka, Mizuki Shinohara, Yasuto Tachikawa: Analysis of Future Changes in Extreme Flow Rates in Japan's First-Class basins Using d4PDF. Journal of JSCE B1, vol76, No1, pp.140-152,2020.

2. Yasuto Tachikawa, Tomohiro Tanaka: http://hywr.kuciv.kyoto-u.ac.jp/products/1K-DHM/document/1K-DHM-event-ver410.pdf

Keywords: climate change, d4PDF, Japan

Keiichiro Kitaguchi
Kyoto University Graduate School of Engineering Department of Civil and Earth Resources Engineering Hydrology and Water Resources Laboratory
Mail: Kitaguchi.keiichirou.84x@st.kyoto-u.ac.jp