

THE ANALYSIS OF FUTURE FLOOD RISK IN HOKKAIDO, NORTHERN JAPAN, USING DATABASE FOR POLICY DECISION MAKING FOR FUTURE CLIMATE CHANGE (d4PDF)

TOMOHIITO J. YAMADA

Faculty of Engineering, Hokkaido University, Sapporo, Japan, tomohito@eng.hokudai.ac.jp

TSUYOSHI HOSHINO

Graduate School of Engineering, Hokkaido University, Sapporo, Japan

ABSTRACT

It is important to develop a plan to adapt to future heavy rainfall because heavy floods have frequently occurred in Japan over the past few years. This study examined the influence of climate change on rainfall characteristics over river basins in Hokkaido, Japan. We used dynamical downscaling to perform large ensemble regional climate experiments with a 5-km grid spacing from the d4PDF database for policy decision-making for future climate change. To evaluate the flood risk from various viewpoints, targets for dynamical downscaling were added: heavy rainfall events under the 2-K warmer condition and full 1-year dynamical downscaling for the past and 4-K warmer conditions. The results enabled us to quantify the influence of the degree of global warming on the annual maximum heavy rainfall and rainfall volume before heavy rainfall events. This research contributes to the expert committees for adaptation planning.

Keywords: climate change, adaptation, flood risk, dynamical downscaling, d4PDF, NHRCM

1. INTRODUCTION

Heavy floods have occurred frequently in Japan in recent years. This has led governments to consider the flood risk associated with climate change and devise plans to adapt to this. The adaptation measures for future extreme flood has been discussing as worldwide issues (Yamada, 2019). This study uses dynamical downscaling (DDS) to make large ensemble regional climate data with a 5-km grid spacing from the d4PDF database for policy decision-making for future climate change (Mizuta et al., 2016). The previous study based on 5-km grid spacing d4PDF shows the risk of heavy rainfall due to tropical cyclone increases under 4-K warmer climate condition (Hoshino et al., 2020). This data can be used for risk assessment (e.g. flood risk, Figure 1). To evaluate the flood risk from various viewpoints, we conducted DDS for heavy rainfall events under the 2-K warmer condition, as well as for a full year under the past and 4-K warmer conditions. The downscaling for the 2-K warmer condition enables quantification of the influence of the degree of global warming on the annual maximum heavy rainfall volume and hourly rainfall intensity. The full 1-year downscaling enables quantification of the rainfall volume that falls before annual maximum heavy rainfall events (prior rainfall). The prior rainfall volume affects soil moisture and can increase the peak discharge (e.g., the flood event in the Tokachi River basin in 2016). This research contributed to the expert committees for future flood control of the Hokkaido Development Bureau and Hokkaido Prefecture and the Ministry of Land, Infrastructure, and Transport.

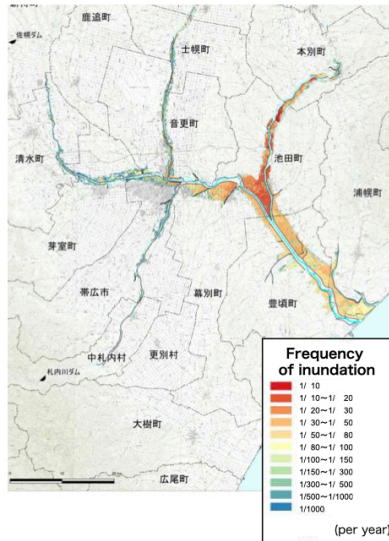


Figure 1. Frequency of inundation (inundation depth is greater than 1 m) over the Tokachi River basin (Hokkaido regional development bureau and Hokkaido prefecture, 2019)

2. DYNAMICAL DOWNSCALING

This research uses d4PDF, which consists of large ensemble climate simulation results (Past climate, total 3,000 years; 2-K warmer climate, total 3,240 years; 4-K warmer climate, total 5,400 years) with a 20-km grid spacing for the DDS, which converts the horizontal resolution from 20 km to 5 km. We conducted DDS using the NHRCM regional climate model (Sasaki et al., 2011) for annual maximum rainfall events over the Tokachi (upper area of the Obihiro reference point) and Tokoro (upper area of the Kitami reference point) River basins in Hokkaido, Japan, under the 2-K warmer condition. The DDS for the other two conditions had already been conducted as part of the “Strategic Project with Special Support (Grand Challenge)” of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) in 2017. We also conducted DDS for a full year DDS for the past and 4-K warmer conditions.

3. RESULTS

Figure 2 shows the frequency of the annual maximum rainfall volume over the Tokachi River basin due to the rainfall after DDS (d4PDF-5kmDS) and Figure 3 shows that of rainfall intensity. Both frequencies are similar to the observed results (Yamada et al., 2018). The d4PDF-5kmDS includes many rainfall events that exceed the maximum recorded rainfall volume; this means that this dataset is effective for evaluating low probability heavy rainfall events. The rainfall volume and rainfall intensity under the past, 2-K warmer, and 4-K warmer climates are both larger, in this order.

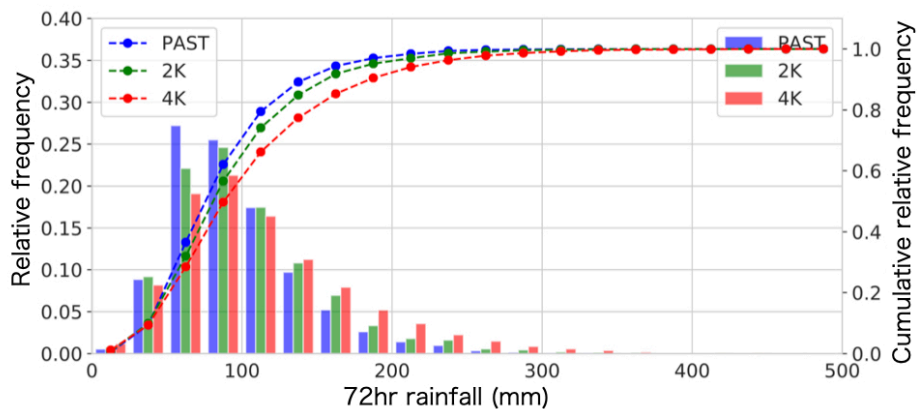


Figure 2. Frequency of the annual maximum rainfall volume over the Tokachi River basin

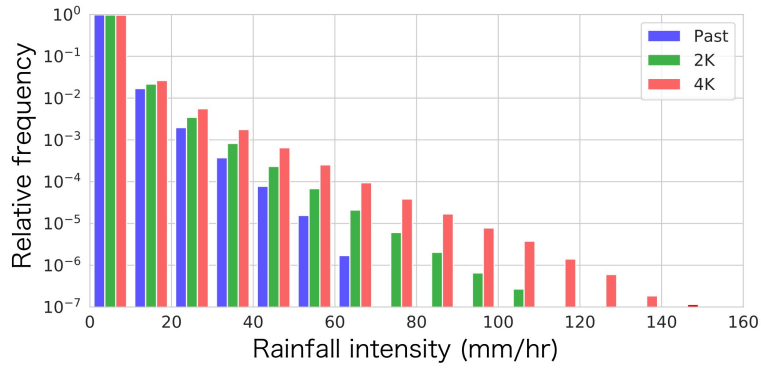


Figure 3. Frequency of rainfall intensity over the Tokachi River basin

Figure 4 shows the prior rainfall volume from 1 to 30 days before annual maximum rainfall events. The figure shows that the prior rainfall volume of the Past experiment is similar to the observations. The median values are almost same, while the 95th-percentile value of the 4-K warmer experiment is bigger than that of the Past experiment. This suggests that rainfall events when the initial soil condition is wetted frequently occur under the warmer climate. Figure 5 shows the annual maximum 72-h rainfall volume and prior 30-days rainfall volume. The Past and 4-K warmer experiments include rainfall events that exceed the maximum values of both the 72-h rainfall volume and prior 30-days rainfall volume. The frequency of such heavy rainfall is higher under the 4-K warmer climate than under the Past climate. These rainfall events are un-experienced and are required for risk assessment.

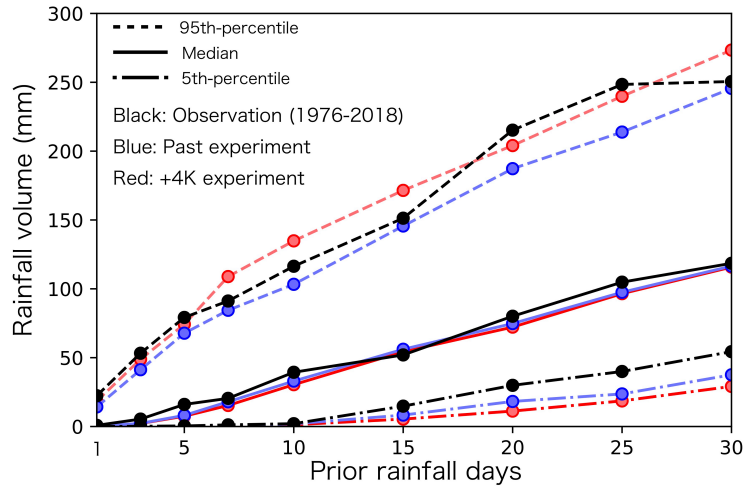


Figure 4. Prior rainfall volume over the Tokachi River basin

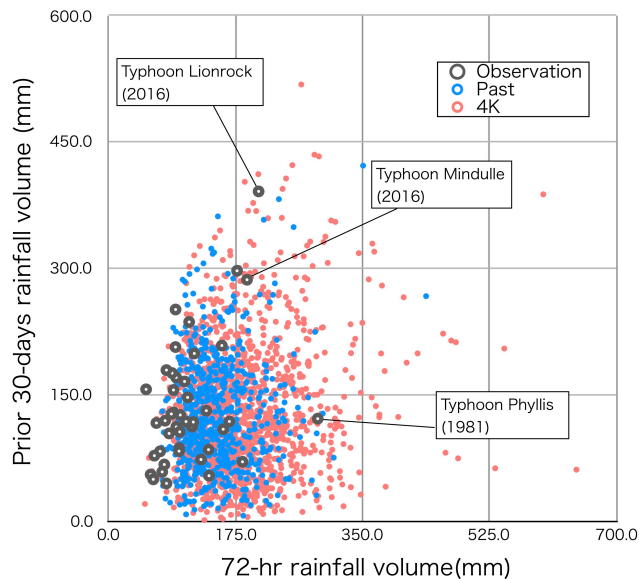


Figure 5. Annual maximum 72-h rainfall volume and prior rainfall volume over the Tokachi river basin (two rainfall events that occurred in 2016 were plotted as exceptions)

4. CONCLUSIONS

This study used DDS to evaluate flood risk from various viewpoints. The results enable quantification of the influence of the degree of global warming on the annual maximum heavy rainfall and rainfall volume that falls before heavy rainfall events. This will contribute to the expert committees on future flood control.

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