Changes in River Plan Target Precipitation due to Climate Change

(Study period: FY2018-)

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key words: climate change, ensemble climate model data

1. Introduction

In recent years, we often recognize the manifestation of the impact of climate change, such as disasters caused by frequent heavy rain. According to the 5th IPCC Report, there is no room to suspect the warming of climate system and the expansion of damage by the impact of climate change may become more serious in the future. Under such circumstances, shift to river development considering climate change is urgently required.

The NILIM is studying a method of reflecting the impact of climate change in the target precipitation of river development plan. This paper introduces the results of analysis on changes in the target precipitation of river development plan, conducted using the data of long-term ensemble calculation, which is a climate forecast method appropriate for discussion of low-frequent extreme phenomena, which should be covered in river development.

2. Calculation of rainfall variation magnification

The variation magnification of rainfall caused by heavy rain under climate change is calculated by conducting DAD analysis using the rainfall data of multiple long-term ensemble climate models and calculating the ratio of probability scale precipitation based on the past experiment data (climate conditions from 1951 to 2010) and future experiments (climate conditions from 2051 to 2110). Of the output results of the area experiment that covers the regions of Japan with the resolution of approx. 20 km provided by d4PDF [1)], this paper provides the results of calculation based on two types of output scaled down to the resolution of approx. 5 km using the nonhydrostatic local climate model "NHRCM" of the Meteorological Research Institute for the past experiments and future temperature rise experiments at 2°C and 4°C.

As regions for calculating rainfall variation magnification, the country was divided into several regions. Based on the region division method used practically in the hydrologic and weather fields, the division methods of multiple regions were verified statistically and the validity of region division methods was compared. The region division methods verified were the division method of regions concerning the assumed maximum scale of rain [2)], the division method of regions modified to raise the ratio of identity based on the regional comparison hydrograph [3)], and forecast division by the Meteorological Agency and local seasonal weather forecast[4)]. As a result, from a viewpoint of the identity of the probability distribution of the maximum rainfall in divided regions, no major difference was found in the validity of region division method. For analyzing rainfall variation magnification, we chose the division method of regions concerning the assumed maximum rainfall, which is the division without any river system across the divided regions, considering that it is desirable to conduct an analysis so that rainfall events are not separated in the same river system. Fig 1 shows the division of regions selected.

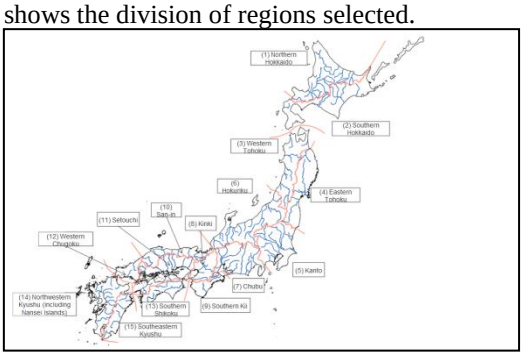

Fig. 1 Division of regions used for the study

The variation magnification of future rainfall was calculated for each region of Fig 1. The calculation procedure is shown below.

1) Organize the relationships between duration of rainfall, size of rain area, and accumulated rainfall in the duration for each year with regard to the data of both past and future experiments (DAD analysis). For the size of rain area, sample the areas where accumulated rainfall is not lower than the threshold value and that are spatially connected.

2) Create the envelope curve of the maximum accumulated rainfall based on the relationship of the accumulated rainfall for each year and the size of rain area.

3) Since the maximum envelope value of the accumulated rainfall of a certain year is equal to the annual maximum rainfall according to the size of rain area of the same year, calculate probability rainfall with Gumbel distribution using the maximum accumulated rainfall of each year for each size of rain

area.
4) Determine the rainfall variation magnification by obtaining the ratio of probability rainfall values calculated in both past and future experiments.

By conducting 2) to 4) for each duration of rainfall, it is possible to obtain the rainfall variation magnification by combining arbitrarily the size of rain area and the duration of rainfall.

3. Calculation results of rain variation magnification

As an example of the calculation results, Figures 2 and 3 provide the variation magnification of 1/100 probability rainfall for each sea surface temperature model in combination of the size of rain area (1,600 km^2) and the duration of rainfall (24 hours) with regard to the rainfall variation magnification calculated from the data of climate forecast model based on the assumed temperature rise of 2°C and 4°C in future.

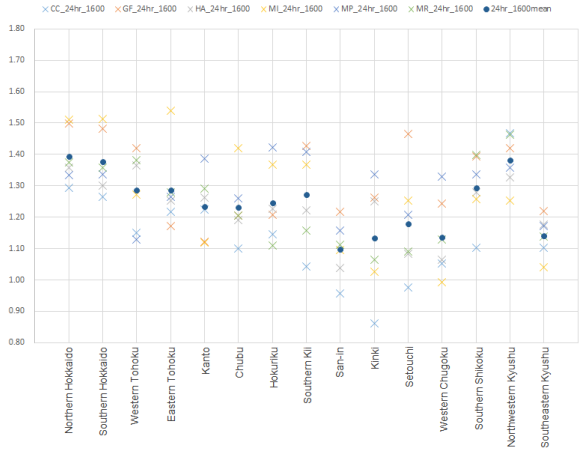

Fig. 2 Rainfall variation magnification of each sea surface temperature model for 24 hours of rainfall duration in the size of rain area of 1600 km^2 at the temperature rise of 4°C.

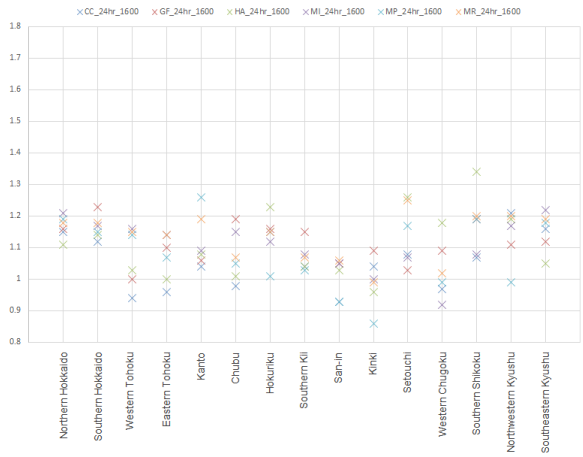

Fig. 3 Rainfall variation magnification of each sea surface temperature model for 24 hours of rainfall duration in the size of rain area of 1600 km^2 at the temperature rise of 2 °C.

At the temperature rise of 4°C, the average value of 6 sea surface temperature models in Northern Hokkaido, Southern Hokkaido, and Northwestern Kyushu regions was relatively larger than other regions. At the temperature rise of 2°C, the average value of 6 sea surface temperature models in Northern Hokkaido and Southern Hokkaido regions was relatively larger than other regions. This would be because the rate of rise in the saturation vapor pressure in Hokkaido becomes relatively large [6] and the rise of sea surface temperature is large in and around Hokkaido and Northwestern Kyushu for sea surface temperature model, since the rate of rise in air temperature becomes large as the latitude of the regions goes up. Using d4PDF, we conducted an analysis on the future variation of the river plan target rainfall and calculated the variation magnification of future rainfall considering the size of rain area and the duration of rainfall for each region. The results of this calculation are expected to be used in the study on external force setting of future river plans.

4. Future schedule

We are going to organize in detail the data on the assumed temperature rise of 2℃ in future in relation to the factor analysis of future changes.

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