Impact assessment of climate change on water resources in the Kiso River basin using NHRCM5km data

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1. Introduction

IPCC AR5 concluded that “warming of the climate system is unequivocal” and “heavy precipitation events are very likely to increase in the frequency and intensity over most of the mid-latitude land masses and over wet tropical regions”. The changes in climatic system will affect the spatiotemporal distribution of water resources and this impact is of a high degree of regional dependence due to the spatial variability of climate change [1]. The Kiso River basin is vulnerable to floods due to high slopes. And watershed water is an important source of downstream city domestic water (e.g. Nagoya-city), irrigation water and industrial water. It is significant to assess the potential changes and impacts of climatic system on water resources at basin scale.

2. Methods

2.1 study area and data

The study area is the Kiso River basin (Figure 1), with an area of 9059 km² and there are three main rivers, including the Kiso River (229 km², flowing through the prefectures of Nagano, Gifu, Aichi, and Mie), the Ibi River (121 km², flowing through Gifu and Mie Prefectures) and the Nagara River (166 km², flowing through Gifu and Mie Prefectures). There are 7 dams with observations and effective storage capacity more than 10⁷ m³ in this basin. NHRCM5km hourly data are used. Present period is from 1981 to 1999 and future period is from 2077 to 2095. Table 1 shows the monthly average precipitation and air temperature in the project periods.

2.2 model description

A water and energy budget based integrated water resource model was used to evaluate future changes of water resources. This model is a combination of Simple Biosphere Model [2] (SiBUC), Rainfall-Runoff-Inundation Model [3] (RRI) and Reservoir Operation Model (ROM). The main advantage of this model is it considers the impact of reservoirs on hydrological cycle and allows description of water and energy at the basin scale. AMeDAS and SDP data were used.
for model calibration and validation. Then, present and future NHRCM5km meteorology data were used to simulate evapotranspiration, river discharge and reservoir inflow.

Table 1. Average NHRCM5km monthly precipitation and air temperature

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<th></th>
<th>Precipitation (mm)</th>
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<tbody>
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<td>154</td>
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<td>238</td>
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<td>154</td>
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<tr>
<td></td>
<td>Future</td>
<td>171</td>
<td>149</td>
<td>204</td>
<td>232</td>
<td>183</td>
<td>213</td>
<td>421</td>
<td>244</td>
<td>294</td>
<td>138</td>
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<tr>
<td>Difference</td>
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<td>13</td>
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<td>22</td>
<td>-141</td>
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<td></td>
<td>Temperature (°C)</td>
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<td>9</td>
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<tr>
<td></td>
<td>Future</td>
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<td>3</td>
<td>7</td>
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<td>22</td>
<td>26</td>
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<td>17</td>
</tr>
</tbody>
</table>

3. Results and discussion

3.1 calibration and validation

Three years’ observations from 1999 to 2001 were used for model calibration and validation. The model was calibrated by the Misogawa Dam inflow and validated by the Agigawa Dam inflow. NSE is used and results show that the values of NSE are 0.75 and 0.7 at Misogawa and Agigawa. Thus, the model has accepted performance in the study area.

3.2 Changes of water resources

During the projected period, annual River discharge at Inuyama station tends to decrease. But there are no obvious changes in winter though precipitation tends to decrease. The probable reason is an increase of snow melting. In the heavy rainfall season from June to September, the average monthly discharge will decrease from present to future excluding July. There is an obvious decrease in August from present to future. Peak flow in September seems to move forward from late of the month to early of the month. Extreme flow (daily maximum) tends to increase during the projected period. It seems to increase a lot in April, June, July and October. Generally, the decrease in total discharge and increase in extreme discharge will bring large challenges to future water resource management.

3.3 Limitations

In this study, only one RCM data source is used. Data from different climate models and different spatial resolution may have different results. It is significant to have more studies using different data source in the future.

Reference


Keywords: Modelling, Evapotranspiration, River discharge

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