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Impact Assessment of Climate Change on Agricultural Water Use by a Distributed Hydrological Model

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1. Introduction

A large amount of water in Monsoon Asia is used for rice paddy, and the mechanism of water use varies decently from one region to another. Agricultural water exerts a great influence on the hydrological cycle in river basins and modeling of this process is crucial to understand the hydrological cycle especially in areas where irrigated agriculture is dominant. Such agricultural water uses, however, were not fully combined in the previously runoff models, although this process is essential for assessing the impact of climate change on agriculture in Monsoon Asia.
In this study, a distributed hydrological model incorporating various agricultural water uses especially in paddy areas was developed and impact assessment of climate change on irrigation was carried out in the Seki River basin located in the Hokuriku region of Japan.

2. Distributed hydrological model incorporating various agricultural water uses

The model developed in this study consists of four sub-models, such as evapotranspiration, cropping pattern/area, agricultural water use, and runoff, so that it enables to estimate cropping area, paddy water requirements, actual intake at main irrigation facilities at any point of the basin, in addition to actual evapotranspiration, soil water content, runoff amount that are normally calculated by many prevailing runoff models. A target basin is divided into 1km-messhed cells and each cell contains the ratio of 5 land-use category as forest, rain-fed paddy, irrigated paddy, upland field and water. Irrigation and crop patterns are also set as agricultural practices in each cell, and then irrigation amount and actual evapotranspiration will be estimated according to cropping stage and soil moisture. In Japan, paddy areas are located far from diversion weirs. Therefore, delivery and distribution system of agricultural water was also modeled and integrated into the developed hydrological model. In addition, snowfall/snowmelt and reservoir operation models were also incorporated for the impact assessment analysis.

3. Analysis data and bias correction

Climate change projections by MIROC (SRES-A1B) were used as input into the hydrological model. Coarse resolution by GCM was nested into 1km resolution by a statistical downscale model. There was discrepancy between the observed and generated meteorological elements. So, bias correction was carried out by a statistical method, taking the gamma distribution to daily precipitation and daily-mean wind velocity, and the normal distribution to daily-mean temperature and relative humidity respectively, for instance. Furthermore, monthly daily-maximum precipitation as extreme events was additionally corrected using the gumbel distribution.

4. Results and discussion

The results obtained are as follows: 1) Snowmelt runoff decreases remarkably in early spring in near future (2046-2065) and the end of 21th century (2081-2100), due to global warming. 2) Actual agricultural intake at the "Itakura" head works decreases especially during puddling periods owing to the decrease in snowmelt runoff mentioned above. 3) Although cropping areas of irrigated paddies do not vary significantly in an average rainfall year, areas in drought years decrease compared to those of the present period (1981-2000). 4) The distributed hydrological model incorporating various agricultural water uses developed in this study can foretell detailed impacts of climate change on irrigation as well as that of discharge.