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Spatial Downscaling of Precipitation from GCMs for Assessing Climate Change over Han River and Imjin River Watersheds

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Abstract: The main objective of this study, "Spatial Downscaling of Precipitation from GCMs for Assessing Climate Change over Han River and Imjin River Watersheds", is to carry out over Han River and Imjin River watersheds. To this end, a statistical regression method with MOS (Model Output Statistics) corrections at every downscaling step was developed and applied for downscaling the spatially-coarse Global Climate Model Projections (GCMPs) from CCSM3 and CSIRO with respect to precipitation into 0.1 degree (about 11 km) spatial grid over study regions. The spatially archived hydro-climate data sets such as Willmott, GsMap and APHRODITE datasets were used for MOS corrections by means of monthly climatology between observations and downscaled values. Precipitation values downscaled in this study were validated against ground observations and then future climate simulation results on precipitation were evaluated for the projections.

Keywords: Downscaling, Precipitation, Climate Change Assessment

I. INTRODUCTION

A number of studies for downscaling of climate variables from GCM outs have been carried out, but a very limited number of studies with high resolution of grid information have been accomplished in Korea. Furthermore, these studies focus on a specific scenario such as A1B or A2 or the grid resolutions are not appropriate in order to apply in watershed scales. A dynamical downscaling method can achieve this purpose, but this method is computationally very expensive and a general method of statistical downscaling does not account for the spatial and temporal variability of climate variables appropriately.

II. SPATIAL DOWNSCALING OF PRECIPITATION

A. *Study Area and Methodology*

Han River and Imjin River watersheds were selected for future climate change study (Figure I). Han River watershed, which drains about 26,355 km^2, is the fundamental water resources to the central part of South Korea with a series of dams. High densely built up areas are located along Han River including Seoul which is the capital of South Korea. Imjin River watershed, which drains about 8,118 km^2, is located next to Han River watershed and has been affected by the floods. Furthermore, many areas in two watersheds, especially Imjin River watershed, belong to North Korea. It means that the water is controlled by North Korea and it is very difficult to protect for the extreme events such as floods.

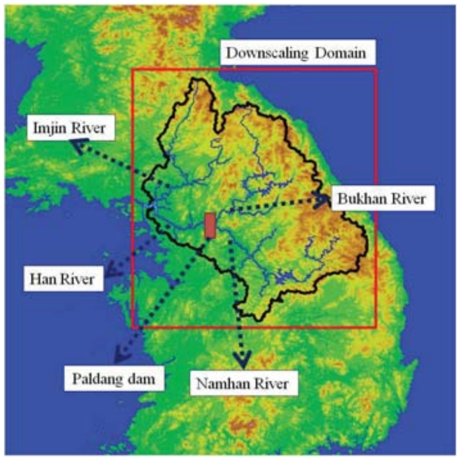

FIGURE I. STUDY AREA AND SIMULATION DOMAIN

Furthermore, many areas in two watersheds, especially Imjin River watershed, belong to North Korea. It means that the water is controlled by North Korea and it is very difficult to protect for the extreme events such as floods.

For this study, a statistical regression method with MOS (Model Output Statistics) corrections at every downscaling step is developed and applied for downscaling the spatially-coarse Global Climate Model Projections (GCMPs) from CCSM3 and CSIRO with respect to precipitation into 0.1 degree (about 11 km) spatial grid over study regions. The spatially archived hydro-climate data sets such as Willmott, GsMap and APHRODITE datasets are used for MOS corrections (Kure et al, 2013a; 2013b).

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B. Validation

To build confidence in using the statistical downscaling method for the future period, the downscaled precipitation and air temperature have been validated against ground observations from KMA stations considering data availability and period within the target watersheds (Han River and Imjin River watershed) by graphical comparisons such as time series and quantile-quantile plots as well as by statistical tests.

The plots in Figure II shows example of the graphical comparisons of the downscaled GCM (CCSM3 and CSIRO) simulated monthly precipitation against ground observations during the historical January 1961 – December 1999 period. The observed mean, STDEV, and RMSE values are quite similar between simulations (by downscaling from GCMs) and observations. From the results of graphical comparisons and statistical tests, it may be concluded that the performance of developed statistical downscaling method is within acceptable accuracy and it can be used for applying future climate change projections over study region.

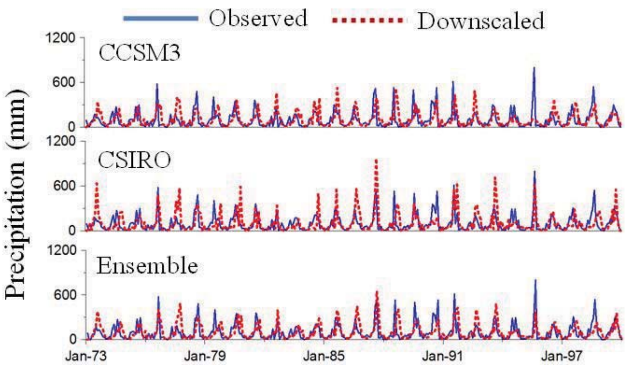

FIGURE II. Comparisons of downscaled and observed monthly precipitation during 1973 – 1999 at Choongju station

III. FUTURE CLIMATE CHANGE ASSESSMENT ON PRECIPITATION

It is difficult to distinguish the precipitation trends among scenario families with respect to their annual values, but it can be seen different trends in their 10-year moving average values. A1B and A2 families show the upward trends up to the middle of 21st century, but A2 family shows the downward trends toward end of 21st century with respect to annual precipitation and annual JJA mean precipitation. All scenario families do not show much of trends in annual DJF mean precipitation.

However, spatial comparison of 30-year average annual precipitation between historical period (1970 – 1999) and ensemble average of 6-realization are shown in Figure III As shown in Figure III, it is clear that all study regions are wetter than historical 30-year period (1970-1999 and these wet areas are gradually wider toward end of 21st century.

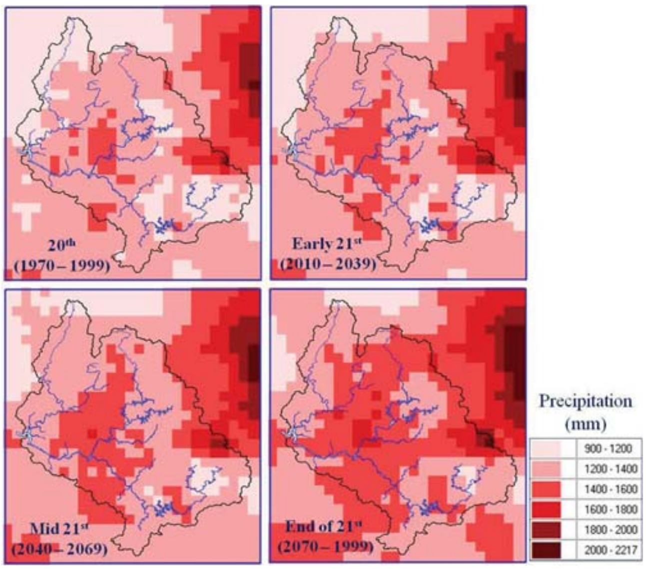

FIGURE II. Spatial comparison of historical (21st: 1970 – 1999) and GCM-based (ensemble-average of 6-realization) 30-year average annual precipitation for early 21st: 2010-2039, mid 21st: 2040-2069, and end of 21st: 2070-2099 over study region

IV. CONCLUSIONS

From the analysis of the statistically downscaled GCMPs, the following conclusions related to the future climate conditions may be stated;

- The ensemble averages of precipitation are slightly increasing toward 21st century.
- Spatial distribution of changes in 30-year average precipitation shows that the Imjin River and Bukhan River watersheds are significantly wetter than historical period at the early-, mid- and end of the 21st century.

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