Kriging Approach to Quantile Delta Mapping (QDM) for Spatial Downscaling of Climate Change Scenario

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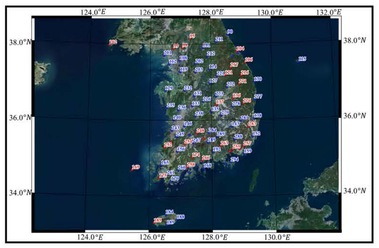
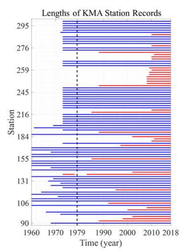
Introduction

- Rainfall simulation by climate model is generally provided at coarse grids and bias correction is routinely needed for the hydrological applications.
- This study aims to explore an alternative approach to downscale daily rainfall simulated by the regional climate model (RCM) at any desired grid resolution along with bias correction using a Kriging model, which better represents spatial dependencies of distribution parameters across the watershed.
- The Kriging model also aims to reproduce the spatial variability observed in the ground rainfall gauge.
- The proposed model is validated through the entire weather stations in South Korea and climate change scenarios simulated by the five different RCMs informed by two GCMs.
- The results confirmed that the proposed spatial downscaling model could reproduce the observed rainfall statistics and spatial variability of rainfall.
- The proposed model further applied to the climate change scenario.
- A discussion of the potential uses of the mode is offered.

Observation Rainfall data and meteorological factors

- The BK-QDM method a spatial interpolation technique that considers grid cell uncertainty through Bayesian Kriging of parameter of each meteorological factor's optimum distribution unlike the existing spatial interpolation technique of offset correction meteorological factor of each spot.
- The spatial inconsistency occurring due to "0" value in the offset correction of daily unit meteorological factor and the average of Kriging implementation are identical, but it is the model to solve the problem of underestimating the distribution calculated in the big distribution.
- This model calculates the parameter of meteorological factor through Bayesian Kriging by grid cell, and the calculated result is connected with QDM to implement spatial specification of climate change scenario.



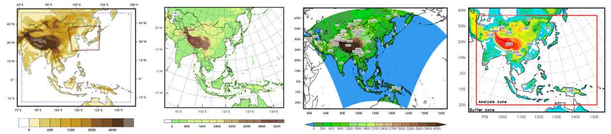


❖ Observation data - KMA ASOS

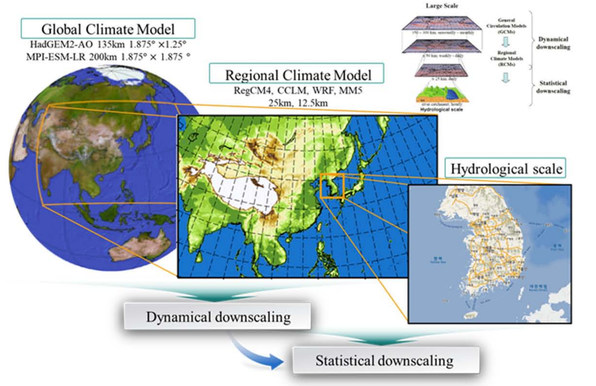
- The Korean Meteorological Administration (KMA; http://www.kma.go.kr/) operates more than 90 Automatic Synoptic Observation System (ASOS) gauges across the country; 60 stations in the Korea are used for the study.

❖ Climate Change Scenario– CORDEX-RCMs

- CORDEX has 14 domains to predict climate change in all regions of the world, and Korea has selected and used scenarios related to East Asia, the entire East Asia domain.
- CORDEX was established as a global framework for improving coordination of international efforts to produce high-resolution regional climate change scenarios downscaled from the Coupled Model Intercomparison Project Phase 5 (CMIP5), using multiple RCMs ensembles for uncertainty reduction.
- CORDEX-EA in Korea provides climate change scenario based on Region Climate Model (RCM) through the Dynamic Downscaling from (National Institute of Meteorological Sciences, NIMS).

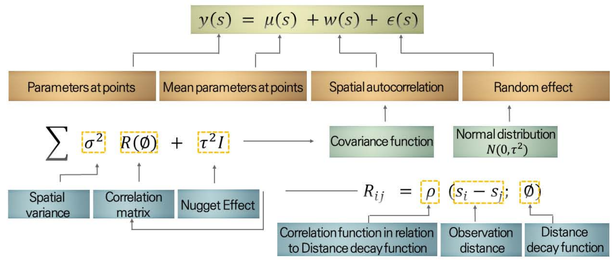


Methodology



❖ Bayesian Kriging-Quantile Delta Mapping Model

- As Kriging model is a field of statistics that is applicable to physical phenomena or data analysis distributed spatially or temporally, it is a model of Geostatistics downscaling that derives reliable conclusions by collecting data distributed spatially or temporally to analyze and use its distribution characteristics and correlations.
- There are various types of Kriging such as Simple Kriging, Ordinary Kriging, Co-Kriging, and General Kriging depending on the application method and input data, but in this study, it is used Ordinary Kriging (OK), which minimizes the error variance without biasing Kriging estimation equation.



- Quantile Delta Mapping (QDM) is mapping the probability distribution of future simulated values to the probability distribution of observed values by using cumulative probability distribution of observed and simulated values through a certain past period in which the observed value and the simulated value exist simultaneously.
- The relative change inherent in Quantiles of precipitation can be reflected in the model, and Quantiles of the simulated results can be systematically modified based on the observed values.

***Eq.* 1**

$$\tau_{s.f}(t) = F_{s.f}^{(t)}[x_{s.f}(t)]$$

$$\tau_{s.f}(t) \in \{0, 1\}$$

***Eq.* 2**

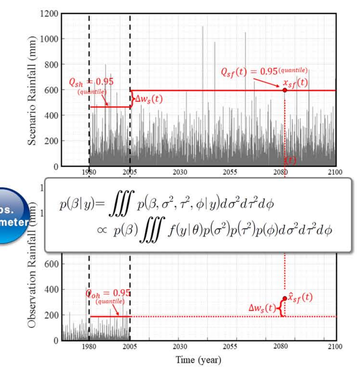
$$\Delta w_s(t) = \frac{x_{s.f}(t)}{F_{s.h}^{-1}[\tau_{s.f}(t)]}$$

***Eq.* 3**

$$\hat{x}_{o.s.h.f}(t) = F_{o.h}^{-1}[\tau_{s.f}(t)]$$

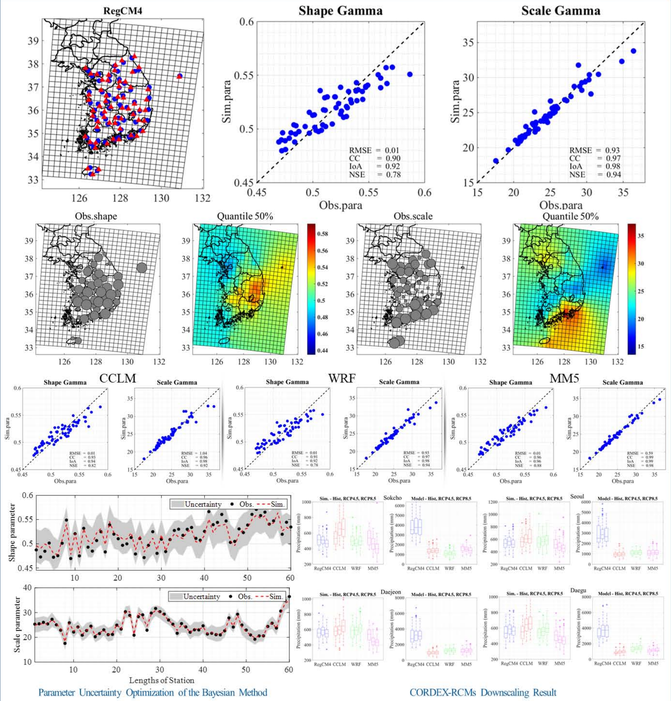
***Eq.* 4**

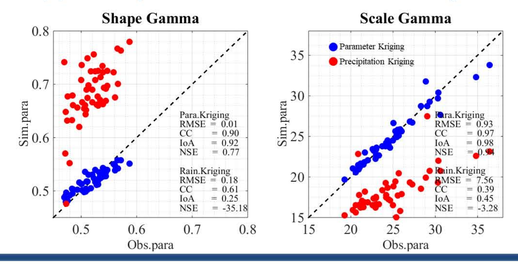
$$\hat{x}_{s.f}(t) = \hat{x}_{o.s.h.f}(t) * \Delta(t)$$



Results

- The Bayesian Kriging verification through the Leave One Out Cross Validation (LOOCV) method resulted in statistical verification results that could trust all Gamma parameters, and the convergence result can be confirmed in the PDF result of the poster distribution of Kriging parameter through Bayesian.
- The 9000 parameters of the grid are simulated, and when the grid scenario degree comes in, the weight information by the parameters is generated. Based on this information, scenario precipitation by QDM and the uncertainty caused by it are estimated.





Conclusions

- In the results through the downscaling model presented in this study, all the BK-QDM model has significant statistical verification values, and provide optimum results in climate change scenario specification as they provide more improved results than existing model.
- Due to increasing climate variability, conservative water resource management that is based on old data may increase risks.
- Also, the current system must actively adopt and utilize future meteorological information.
- In that sense, the findings in this study can be used as basic data for improving delivery of climate information and making relevant decisions.

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