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Integrated Statistical Downscaling and Uncertainty Assessment for Singapore Rainfall

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Abstract—Bridging models called statistical downscaling models are required to connect the global climate model output and the local weather variables for climate change impact prediction. The uncertainty associated with the model should be quantified for reliable climate change impact studies. The sources of uncertainty include natural variability, uncertainty in the climate model(s), downscaling model, model inadequacy and in the predicted results. In this work, a new approach developed by the authors and called BUASCSDSEC (Bayesian uncertainty analysis for stochastic classification and statistical downscaling with stochastic dependent error coupling) is applied to Singapore rainfall. It is a robust Bayesian uncertainty analysis methodology and tools for combined classification and statistical downscaling. It is based on coupling dependent modeling error with classification and statistical downscaling models in a way that the dependency among modeling errors will impact the result of both classification and statistical downscaling model calibration and uncertainty analysis for future prediction. Singapore data are considered here and the uncertainty and prediction results are obtained. For the validation data set, it is observed that the CDFs of the daily predicted samples are consistent with the observed CDF of precipitation. From the results obtained, directions of research for improvement are briefly presented.

***Keywords*—downscaling, uncertainty, rainfall, error, climate change**

I. Introduction

There have been increasing natural hazards such as flooding due to climate change. The impact of climate change on hydrology needs to be assessed to assist in future planning and risk mitigation during extreme flood events. Statistical downscaling models are being widely used in studying climate change impact. For more robust future planning, the uncertainties in the models and results should be modeled and quantified properly [1]. The quantification of uncertainty in the model structure, model parameters and results is very important before using it for impact studies. The error in the model is due to imperfect representation of the real world by the models, parameterization, measurement error and natural variability. Uncertainty is inherent in any numerical models and quantification of uncertainty in the output of the model is very important for future impact analysis. The objective of this study is to apply a new Bayesian uncertainty tool called BUASCSDSEC (Bayesian uncertainty analysis for stochastic classification and statistical downscaling with stochastic dependent error coupling) [5] for combined stochastic classification and statistical downscaling with stochastic dependent error coupling [2] modeled as Gaussian process [3].

II. Study Area in Singapore

The study area and rainfall stations for this research are Singapore which is shown in Figure 1. In this study, the observed rainfall from a Singapore golf station is used. The data from a Global Climate Model (GCM) HadCM3 (coupled Atmospheric and Oceanic model) are used as predictors in downscaling. NCEP (National Centers for Environmental Protection) reanalysis data are used for calibrating and validating the model. The calibration period for this study is from 1980 to 1994 and the validation period is from 1995 to 2000. The predictors for model calibration are chosen from NCEP reanalysis data: 500 hPa geopotential, 850 hPa geopotential, near surface relative humidity, relative humidity at 500 hPa height, relative humidity at 850 hPa height and near surface specific humidity. For illustration, stochastic models are calibrated and validated only for the month of December.

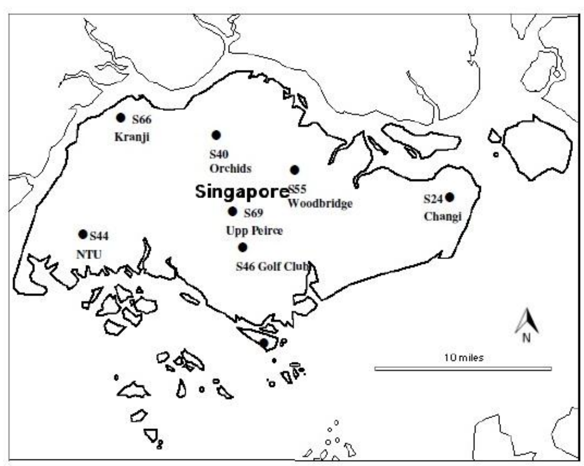

Fig. 1. Study area and location of rainguage stations [4]

III. Results

The model prediction results for the month of December for the validation period is shown here. BUASCSDSEC is implemented to generate time histories samples which indicate which future days are wet and which days are dry before the downscaling of the GCM variables is carried out. The proposed model is calibrated using the calibration data and the model is validated using the validation data.

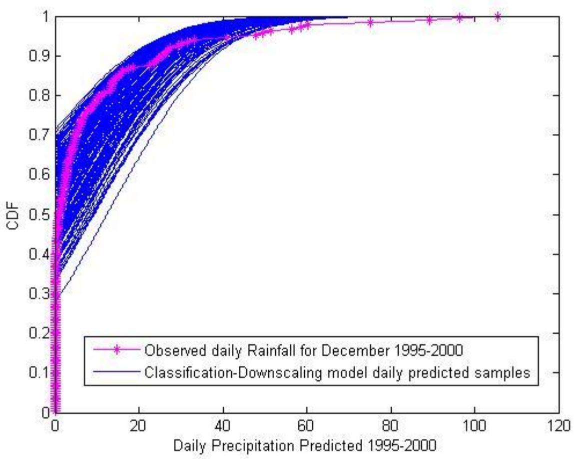

Fig. 2. Cumulative distribution function of the predicted samples obtained from BUASCSDSEC and the real observations

Figure 2 shows the comparison of cumulative distribution function (cdf) of the predicted samples obtained from BUASCSDSEC and the real observations. It is observed that the CDFs of the daily predicted samples are consistent in trend with the observed CDF of precipitation. The uncertainty is smaller for the extreme rainfall and the uncertainty for smaller amount of rainfall is more compared to that for the extreme rainfall. One possible reason for this could be that the uncertainty from the proposed classification model affects the results in the downscaling model. Using BUASCSDSEC, different sources of uncertainty can be captured. Using Bayesian statistical framework, the likelihood for different models can be obtained which can be used for weighting different statistical downscaling models in multi model method for uncertainty quantification.

IV. Conclusions

This paper presents some results using BUASCSDSEC for classification and statistical downscaling coupled with uncertainty quantification and propagation for Singapore rainfall. The uncertainty in GCM will be quantified and propagated in the future work by a newly developed method by the authors for integrating multiple GCMs.

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