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著者(和文)	Zhao Wenpeng
Author(English)	Wenpeng Zhao
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	融合理工学 地球環境共創	系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（工学）
学生氏名： Student's Name	Wenpeng Zhao		指導教員（主）： Academic Supervisor(main)	Tsuyoshi Kinouchi	
			指導教員（副）： Academic Supervisor(sub)		

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This thesis investigated the global warming-induced extreme rainfall changes in Southeast Asia through the establishment of (intensity duration frequency curves) IDF curves, proposed specific adaptation strategies to reduce the potential risks associated with the changes, and further quantified the uncertainty in the development of IDF curves.

Firstly, we introduced a framework to develop the IDF curves in data-sufficient and -scarce cities by using a novel (artificial neural network) ANN model for temporal disaggregation, selected (bias correction) BC methods for spatial downscaling, and the scaling properties of extreme rainfall for interpolation. Our proposed BC method and ANN model outperformed traditional (methods) models. The selected BC methods eliminated the systematic model bias and reduced the associated model uncertainty for the construction of IDF curves for future periods effectively. Rainfall intensity for rarer rainfall events is found to increase more in these cities. However, the large uncertainty arising from the climate models requires us to update the results by using more high-accuracy models. And homogeneity assumption underlying the spatial interpolation needs further investigation in the next step.

Secondly, this framework was further extended to develop the IDF curves in a data-scarce country-Cambodia by using auxiliary (i.e., reanalysis) datasets and climate model datasets. The framework was developed based on improved temporal disaggregation models (i.e., CANN), and the outputs were statistically analyzed based on (zero-inflated generalized extreme value distribution) ZIGEV. A novel flood risk change index was built on the information of various socioeconomic factors, including the population, agriculture, economy, flood impacts on population, etc., as well as the information on projected heavy rainfall change. Subsequently, we developed a province-level flood risk change map in Cambodia and discussed countermeasures to reduce the multidimensional flood-induced risks. The detailed summaries are as follows. 1) The temporal disaggregation model (CANN), designed to simulate the heavy rainfall pattern based on a range of atmospheric variables, is able to reduce the uncertainty arising from the stationarity assumption. Thereafter, (monthly maximum series) MSS from CANN combined with ZIGEV outperformed (annual maximum series) AMS coupled with (generalized extreme value distribution) GEV in reducing the uncertainty from biased disaggregated rainfall; 2) rainfall intensity is projected to increase more in the shorter durations, higher return periods, late-century (than mid-century), especially over Southern and Central Cambodia, which is consistent with the underlying governing physical arguments (e.g., the convective heavy rainfall is estimated to intensify in the future, explaining the higher increase of rainfall intensity in the shorter durations). However, when averaging over the whole of Cambodia, only 10~30% of the rainfall intensity increase can be attributed to warming-induced moisture increase. The remaining increase can be explained by the change in wind convergence and some other atmospheric activities that need further investigation in future work. 3) for flood risk change caused by sub-daily heavy rainfall, Southeastern and Northwestern Cambodia, especially in Phnom Penh city and Kandal province, are detected as the priority regions for strategy adaptation (e.g., optimizing the urban development planning to avoid property loss) and taking mitigation actions to reduce the potential urban (flash) flood risks in the future. 4) for flood risk change caused by long-lasting heavy rainfall, Southeastern and Northwestern Cambodia, especially for the provinces which play a major role in food (rice) production, should update field drainage systems and enhance the international cooperation, especially with countries in the upper Mekong River basin to avoid the adverse impacts of inundation and river flooding on the national food security.

Thirdly, by developing IDF curves, we quantified the impacts of different uncertainty sources associated with the choices of different (regional climate models) RCMs, RCP scenarios (i.e., RCP 4.5 and 8.5), parameter estimation methods (i.e., MCMC, L-moment, and MLE), and with and without BC on the rainfall intensity change, followed by focusing on potential countermeasures to mitigate the multidimensional adverse impacts of global warming under the deep uncertainties. The main conclusions are listed as follows:

1) A comparison between the RCMs with and without BC revealed that BC can efficiently remove the model bias in the historical and future periods. The changes in rainfall intensity with BC were consistent with the literature and the underlying physical mechanisms (i.e., more increase in higher return periods), supporting the application of BC before developing IDF curves; 2) RCMs accounted for the largest uncertainty in the rainfall intensity change, followed by the BC. RCP scenarios and parameter estimation methods provided the comparable and lowest uncertainty. Moreover, these uncertainties (signified by the variance) were by and large proportional to the increasing return period; 3) due to the deep uncertainty, one may hold the opinion that decision-making should be delayed until sufficient knowledge (e.g., convection-permitting models) becomes available. However, deep uncertainty should not be the reason under the condition of increasing urban flood risk, and it is more reasonable to have a flexible and adaptive strategy that can evolve over time with regard to new information, e.g., feedback from the current strategy.

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