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Deterministic hydrological modelling for flood risk assessment and climate change in large catchment. Application to Vu Gia Thu Bon catchment, Vietnam

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Modélisation hydrologique déterministe pour l'évaluation des risques d'inondation et le changement du climat en grande bassin versant. Application au bassin versant de Vu Gia Thu Bon, Viet Nam.

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ABSTRACT

Climate change due to the increase of greenhouse gas emissions is considered to be one of the major challenges to mankind in the 21st century. It will lead to changes in precipitation, atmospheric moisture, increase in evaporation and probably a higher frequency of extreme events. The consequences of these phenomena will have an influence on many aspects of human society. Particularly at river deltas, coastal regions and developing countries, the impacts of climate change to socio-economic development become more serious. So there is a need for a robust and accurate estimation of the variation of natural factors due to climate change, at least in the hydrological cycle and flooding events to provide a strong basis for mitigating the impacts of climate change and to adapt to these challenges.

Vietnam is located in the region of the south East Asia monsoon. As most of the population work in agriculture and inhabitants essentially concentrate at the coastal plain, Vietnam is expected to be one of the countries most heavily affected by the consequences of climate change in the end of 21st century. These challenges urge Vietnam to have suitable policies which help to improve public awareness, as well as capacity to respond to climate change. In order to provide complete insights for local authority to establish better adaptation strategies against the climate change, the PhD thesis focuses on simulating the long term variation of runoff factors for a river system in central Vietnam, the Vu Gia Thu Bon river.

The first part of this study concentrates on constructing a hydrological model which becomes an efficient tool for assessing the variation of stream flow in the future. Due to its advantages, the fully deterministic distributed hydrological model, which is expected to overcome the difficulties in hydrological modelling at large catchment and the lack of data, is chosen for applying in Vu Gia Thu Bon catchment. The model is set up over Vu Gia Thu Bon catchment, approximately 10,350 km^2. This model considers mostly the runoff factors, from surface flow to groundwater flow, from infiltration to evapo-transpiration. This model is calibrated and validated against daily data and monthly data in the period of 1991-2000 and 2001-2010, respectively. The second part is to evaluate the impact of climate factor changes on runoff at the end of the 21st century. For this

purpose, 3 climate scenarios (CCSM3.0, MIROC- 3.2, ECHAM 5) for the period 2091-2100 were estimated from the present observations of the period 1991-2000 by using delta change factors obtained from downscaling process. These scenarios were input to the validated hydrological model for determining the runoff in the future. The change tendency is shown by the difference in the present and future peak flow, base flow and return period. In the third part, a hydraulic model has been developed for the flood prone area (1,780 km^2) to map the inundation area corresponding with the previously described streamflow variations. Scale variability of inundation area under the impact of climate change was evaluated to demonstrate the severe consequences of global warming at Vu Gia Thu Bon catchment. Finally, flood and land use maps are analyzed to estimate damages caused by the streamflow increase.

RESUME

Le changement climatique dû à l'augmentation des émissions de gaz à effet de serre est considéré comme l'un des principaux défis pour les êtres humains dans 21ème siècle. Il conduira à des changements dans les précipitations, l'humidité atmosphérique, augmentation de l'évaporation et probablement augmenter la fréquence des événements extrêmes. Les conséquences de ces phénomènes auront une influence sur de nombreux aspects de la société humaine. Particulièrement à deltas des fleuves, les régions côtières et les pays en développement, les impacts du changement climatique au développement socio-économique sont plus graves. Donc, il y a une nécessité d'avoir une estimation robuste et précise de la variation des facteurs naturels dus au changement climatique, au moins dans les événements de cycle et d'inondation hydrologiques pour fournir une base solide pour atténuer les impacts du changement climatique et s'adapter à ces défis.

Le Vietnam est situé dans la région de la mousson en Asie du Sud. La plupart de la population travaille dans l'agriculture et habitants essentiellement se concentrer à la plaine côtière, le Vietnam est prévu l'un des pays les plus durement touchés par les conséquences du changement climatique à la fin du 21e siècle. Ces défis exhorter le Vietnam d'avoir une des politiques appropriées qui contribuent à améliorer la sensibilisation du public, ainsi que la capacité à répondre aux changements climatiques. Afin de donner un aperçu complet de l'autorité locale d'établir de meilleures stratégies d'adaptation contre le changement climatique, la thèse accent sur la simulation de la variation à long terme des facteurs de ruissellement pour un système de rivière au Vietnam système fluvial central, Vu Gia Thu Bon.

La première partie de cette étude se concentre pour construire un modèle hydrologique qui est l'outil d'évaluation de la variation de débit d'eau à l'avenir. En raison de ses avantages, le modèle hydrologique distribué totalement déterministe, qui devrait à surmonter les difficultés dans la modélisation hydrologique aux grands bassins versant et aux zones manquée données, est choisi pour appliquer dans Vu Gia Thu Bon bassin versant. Le modèle est mis en place au cours Vu Gia Thu Bon versant, à environ 10,350 km^2. Ce modèle considère la plupart des facteurs de ruissellement, de l'écoulement de surface vers les eaux souterraines flux, de l'infiltration de l'évapo transpiration. Ce modèle

est calibré et validé avec les données quotidiennes et les données mensuelles pour la période de 1991-2000 et 2001-2010, respectivement. La deuxième partie est d'évaluer l'impact des changements des facteurs climatiques à ruisseler à la fin du 21^{e} siècle. A cet effet, trois scénarios climatiques (de CCSM3.0, MIROC- 3.2, ECHAM 5) dans la période de 2091 à 2100 ont été calculés sur la base d'observation actuelle de la période de 1991 à 2000 en utilisant les facteurs de changement delta lesquelles l'obtention du processus de régionalisation. Ces scénarios ont été saisis au modèle hydrologique validé pour déterminer la course au large à l'avenir. La tendance de changement est montrée par la différence dans le présent et l'avenir de débit de pointe, le débit de base et la période de retour. En troisième partie, un modèle hydraulique ont été développés pour les inondations zone sujette (1,780 km^2) pour cartographier la zone d'inondation correspondant à des variations de flux ci-dessus. Échelle variabilité de zone d'inondation sous l'impact du changement climatique a été évaluée à démontrer des conséquences catastrophiques du réchauffement climatique à Vu Gia Thu Bon bassin versant. En dernière partie, la carte des inondations et de l'utilisation des terres carte sont analysés afin de compter les dommages causant l'augmentation du débit des cours d'eau.

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