IMPACT OF CLIMATE CHANGE AND RESERVOIR OPERATION ON THE RIVER DISCHARGE IN THE UPPER CHAO PHRAYA RIVER BASIN, THAILAND

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1. INTRODUCTION

The Upper Chao Phraya River basin is located in the northern of Thailand which covers 109,973 km^2 of watershed area or approximately 22 percent of country's area. Bhumibol and Sirikit reservoirs are the main structural measure to regulate surface water in the basin and also influence to nearby basin of Lower Chao Phraya River basin. Operating the reservoir is very difficult due to unpredictable of meteo-hydrology, which is the main driven factor. For example, in 2011, the flood in Chao Phraya River basin caused 4th largest damage (by World Bank) of world natural disaster events. In contrast, in 2012, there was insufficient water to supply for growing rice in off-seasonal period because of low water storage in the reservoirs. Actually a fluctuation of storage volume in reservoir from season to season and year to year is normal.

The aim of this paper is to investigate river discharge couple with reservoir operation module using H08 model in Upper Chao Phraya River basin, both in the past and future using Global Climate Model (GCMs) which its results are available from the World Climate Research Program's Coupled Model Intercomparison Project Phrase 3.

2. UPPER CHAO PHRAYA RIVER BASIN

The considered study area can be classified for four sub-catchments namely; Ping, Wang, Yom, and Nan based on topographical perspective as shown in **Fig.1**. Based on statistical recorded of rainfall and discharge volume data, an average 30 years (1982-2012) over the basin of 1,133 mm/year and 22,624.17 x 10^6 m^3 about 83 percent occurred in rainy season and only 12 percent generated during dry period (at basin outlet C.2 station) in that order.

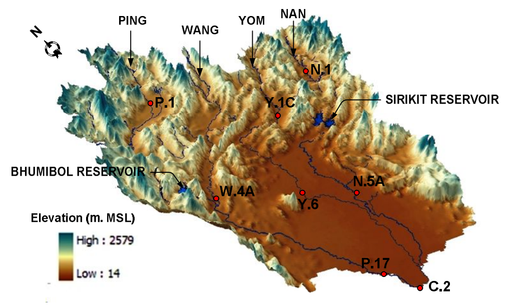

Fig. 1 Upper Chao Phraya River basin and main gaging stations

For the land use there is around 60 percent proportional to forest, 35.6 percent is agricultural sector, and 4.5 percent belongs to wet-land, urban area and so forth.

There are two large reservoirs as structural measure to regulate water resources in the basin namely Bhumibol and Sirikit reservoirs. Bhumibol reservoir is located on Ping River which covers 26,386 km^2 of watershed area with storage volume of 13,462 x 10^6 m^3. Sirikit reservoir is on Nan River and has 13,130 km^2 of drainage area also 9,510 x 10^6 m^3 of total volume. Both reservoirs (Bhumibol and Sirikit) are operated since their completion of construction in 1964 and 1972 respectively. The influenced reservoirs operating area are not only Upper Chao Phraya River basin but also Lower Chao Phraya River basin subjected to their operating of both reservoirs.

To calibrate and validate model performance the main gaging stations of inflow into Bhumibol reservoir, W.4A, Y.1C, Y.6, and inflow into Sirikit reservoir were selected for comparing correlation between model and observed river discharge data.

3. METHODOLOGY

The global and regional water resources model called H08 was developed by Hanasaki et al.,(2008), the model comprises of six modules namely, Land surface module, River module, Environmental flow module, Withdrawal module, Crop growth module, and Reservoir operation module.

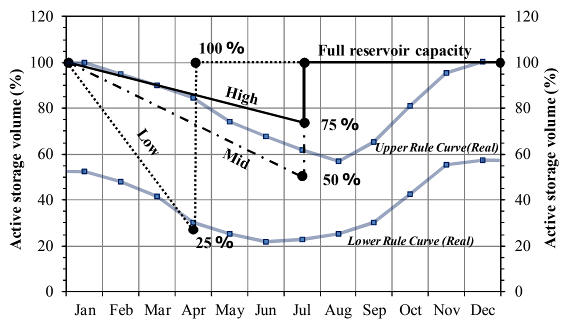

Fig. 2 A simplified upper reservoir operation rule curve

In this study we used a simplify reservoir operation module that was a special developed option to simulate Bhumibol and Sirikit reservoirs as presented in **Fig.2**. Three options of upper reservoir operation rule curve namely; High, Mid, and Low all cases mean the minimum storage is not less than 75, 50, and 25 percentage of active reservoir capacity respectively during simulated time period. To simulate the H08 in this study, the model

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required three components; first is map data, for the upper Chao Phraya River basin, 5’ x 5’ minutes (longitude x latitude) or about 10 km. x 10 km. in grid size resolution. Secondly, meteorological forcing input data (eight variables) as follows; surface air temperature, specific humidity, wind speed, surface air pressure, short wave downward radiation, long wave downward radiation, rainfall, and albedo here-after is called K10 data set (Kotsuki et al., 2010). Finally the core computation processing part is Fortran source code and Bourne shell script to command the source code running on UNIX computer environment.

4. RESULTS AND DISCUSSION

A monthly river discharge simulated results of couple three modules; land surface, river, and reservoir operation module, between 1981-2004 (calibration and validation period) were shown good agreement between model simulation and observation river discharge data by 0.803 of R^2 correlation index agreement at C.2 station (**Fig.3**).

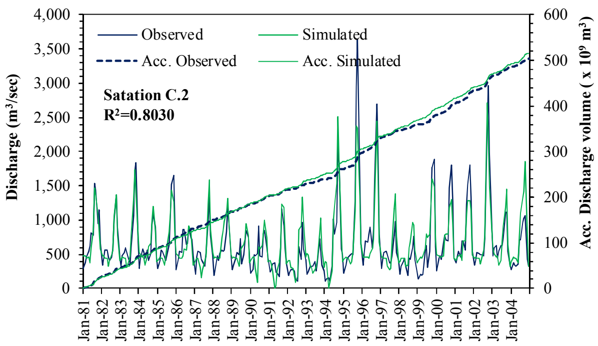

Fig. 3 Comparison on river discharge for C.2 gaging station

For the stations inside each sub-basin (Ping, Wang, Yam, and Nan), namely W.4A, Y.1C, and Y.6 the coefficient of R^2 value were vary between 0.91 - 0.76.

In terms of inflow estimation into the reservoirs, the model simulation was under-estimate of observation data about 24 and 42 percent for both Bhumibol reservoirs and Sirikit reservoirs respectively.

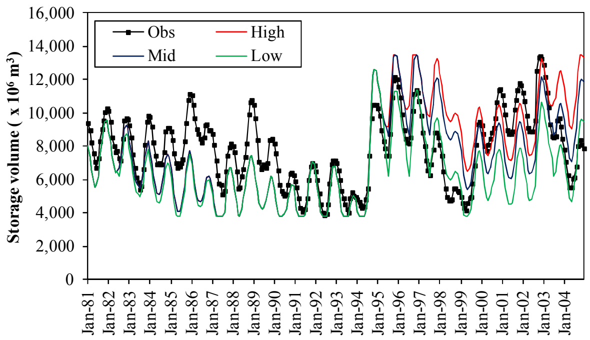

Fig. 4 Simulated of storage volume for Bhumibol reservoir

Actually a real reservoir operation is very complicated as it is not only natural predominated driven but also included by management policy, in fact that very difficult to model. A long term simulated reservoir regulation by means of the simplified reservoir operation rule curves presented good results to mimic observed reservoir storage volume. In case of Bhumibol reservoir that depicted in **Fig.4** represented the ability of reservoir operation module and the applicable of simple governed rule curve to capture a general trend of observed storage data which was subjected by complicated reservoir operating.

For the climate projection and couple with reservoir operation module, the study was selected from the Couple Model Intercomparison Project Pharse3 (CMIP3) and chosen miroc3_2_medres (m32m) for precipitation, surface air temperature and long wave downward radiation dataset of A1, A2, and B1 scenarios. All scenarios show slightly different effect on river discharge (**Fig.5**), but in general river discharge in the upper Chao Phraya River basin (C.2) trend to be decreased especially during dry period (Jan – May).

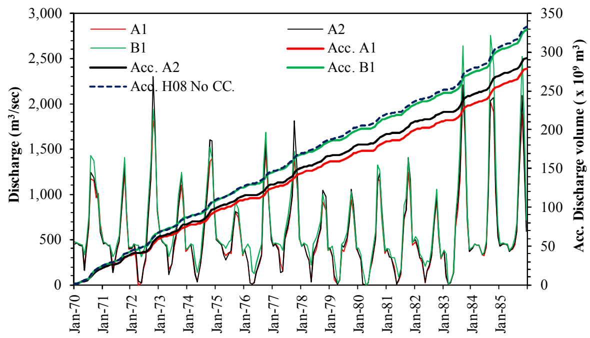

Fig. 5 Effect of climate change on river discharge (C.2 station)

5. CONCLUSIONS

In summary, the application of H08 model, regional downscale version, shows great potential to simulate and forecast river discharge as well as reservoir storage with the good correlation to observed data. The simple reservoir operation rule curves, actually is not real but is able to reproduce general trend of storage for the multi-purposes reservoir operating like Bhumibol and Sirikit reservoirs. For the controversial issue like climate change, three cased scenarios of CMIP3 data set were studied and it reveals that upper Chao Phraya River basin has clearly trend decreased on river discharge during dry season, on the other hand there will slightly effect during wet period.

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