Assessing grid size effects on inundation and groundwater using hydrological model in the Lower Mekong River basin

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1. INTRODUCTION

Annual floods and inundation area have disastrous impacts and cause destruction of water resource, On the other hand, it contributes enhance amount of groundwater with is a positive aspect of flood. Spatial resolution is important in study the interaction between flood and groundwater. Digital Elevation Map was extracted using GIS with grid sizes of 250m and 1000m. It extends from 90m resolution (Shuttle Radar Topography Mission) to 250m and 1000m by bilinear resample technique from ArcGIS. The main objective of this study to assess grid size effects by spatial and temporal inundation area and groundwater level in Lower Mekong basin.

2. STUDY AREA

The Mekong River, the largest inundation area and river in South East Asia, is an international river over six countries; China, Myanmar, Thailand, Lao PDR, Cambodia, Vietnam **(Fig.1)** and it has rich water resource, forest resource and aquatic resources. It is estimated length is 4350 km making it the world's 12th-longest river (S.Liu et al., 2009). Annual precipitation average about 1680mm. The Mekong flood season is from July to December with an average discharge 25000 m^3/s.

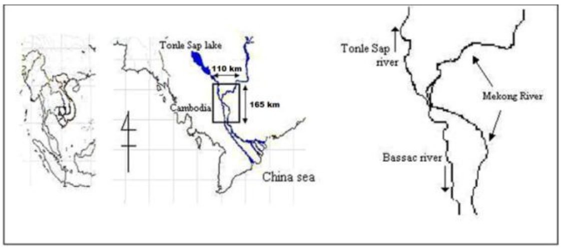

Fig.1 Lower Mekong River

3. METHODOLOGY AND DATA

As the boundary conditions in the flood simulation of rivers, water level data at Kampong Cham, upstream of the Mekong, at Prek Kdam of Tonle Sap, at Tan Chau, downstream of the Mekong and at Chau Doc of Bassac (**Fig.2**). Water level data at Phnom Penh is used for calibration of the model simulation. Those data were periodically obtained by the Mekong river Commission (MRC, 1993-2001). Rainfall data was also obtained by the MRC and distributed over the study area using Thissen's method (MRC, 1993-2001). Riverbed elevation data were available at hydrological stations. These elevations are -1.02m at Phnom Penh, -0.93m at Kampong Cham, 0.08m at Prek Kdam and 0m at Tanchau and Chau Doc. Silt is the main soil type of this area and the hydraulic conductivity has been used as 0.1m/s.

Intially, tentative codition has been set as ground surface water depth as 0m; channel water depth as 5m and groundwater level as 5m. Then the model simulates for one-year period using temporal data in 1999. The outputs of each water depth (surface water depth, channel water depth and groundwater depth) have been used as the intial conditions for the long term simulations.

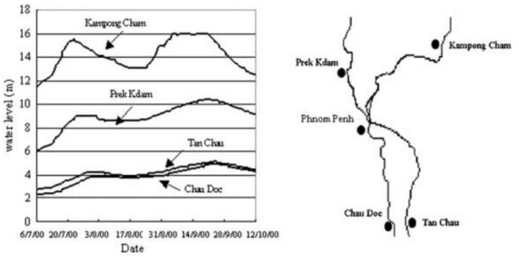

Fig.2 Water levels for boundary conditions

Flood calculation

Continuity equation and Momentum equation is used to estimate flood flow in one dimensional dynamic wave model. We assumed that river width for the Mekong River, Bassac River and Tonle sap River are wide rectangular channel. It was set 1200m for Mekong River and 500m for Bassac River and Tonle Sap River. Manning coefficient for river discharge is assumed as 0.02 (Hagiwara et al., 2002)

Inundating flow

This model also consists of continuity equation and momentum equation in two directional non-uniform flow used for water distribution in inundation areas. We have ignored non-linear term to avoid complex of calculation. The Manning coefficient of the inundation flow has been selected as 0.05

Overflow

For the overflow discharge formula river and floodplains, it generates complete flow and submerged flow under supercritical and sub critical flow. A complete overflow occurs when flood water flowing to dry land through the colmatage cut. In contrast, flowing to wet areas are called submerged overflow. The overflow width is set as 10m.

Key words: Groundwater, Inundation, Hydrological Model, Lower Mekong Basin
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Groundwater

We assumed a uniform soil structure and uniform aquifer properties. An impermeable layer exists 15m below the groundwater and the average groundwater elevation of the area is 10m above mean sea level. Therefore, we set the impermeable layer at -5m elevation. Evapotranspiration flux is assumed as 150mm/month for the whole season (Nawarathna and Kazama, 1999). The specific yield has been estimated as 0.4 (Kazama et al., 2007)

4. RESULTS AND DISCUSSION

Using the numerical solutions of each governing equations, calculations were performed for flood, over flow and inundation flows for several flood events from January 2000 to December 2000. Time interval and ground resolution have been selected as 30s, 2s and 1000m, 250m, respectively. All of model used this time step and ground resolution. **Fig.3** shows the comparison of calculated and observed water levels from July to October at Phnom Penh with two grid sizes. Comparison shows both of grid size estimated water levels are in good agreement with the observation water levels at Phnom Penh.

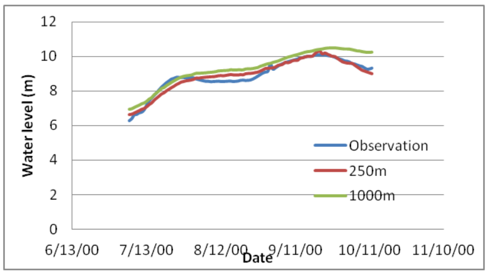
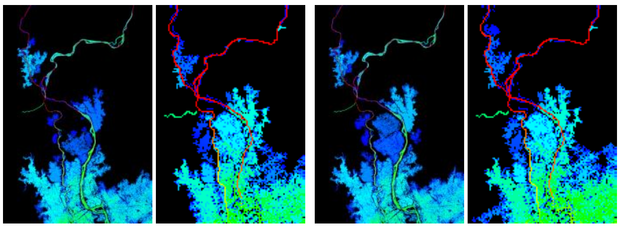


Fig 3 Comparison of calculated and observed water level at Phnom Penh

Inundation area

The estimated temporal and spatial distributions within inundation area in year 2000 by two grid size are present in **Fig 4**. It shows inundation area of 250m is least than 1000m. Almost of inundation cause at downstream condition of both scale because of low land area. Normally, the largest flooding period in the Mekong region is from September to October and the water level reduce after November.



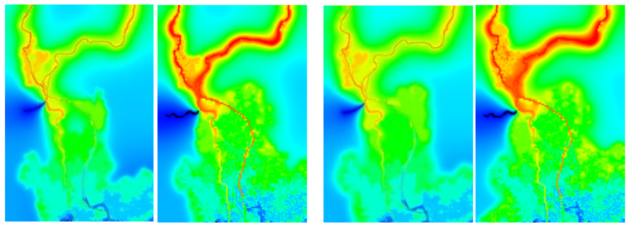
(A) (B) (C) (D)

September October

Fig.4 Temporal and spatial variation of inundation area (A and C: 250m resolution and B and D: 1km resolution)

Groundwater levels and Groundwater storage

The estimated temporal and spatial distributions within groundwater level in year 2000 by two grid size are present in **Fig 5**. This result was used to estimate the groundwater storage by the integration of the difference between highest and lowest groundwater levels.



(A) (B) (C) (D)

September October

Fig.5 Temporal and spatial variation of groundwater level (A and C: 250m resolution and B and D: 1km resolution)

Groundwater storage = $\int (GWL_h - GWL_l) dA \times n_g$

Where GWL_h is the highest groundwater level and GWL_l is the lowest groundwater level. Using this equation, the groundwater storage in the study area has been estimated as 59.11 km^3, 62.08 km^3 (250m) and 64.27 km^3, 67.50 km^3 (1000m) in September and October respectively. It shows that effect of grid size cause difference from groundwater storage. This mean that changes of flood magnitude influences groundwater resource during flood period.

5. CONCLUSIONS

Groundwater resources are influenced by flood water in inundation areas; Numerical models based on the behavior of flood flow, overflow, inundation depth and groundwater levels. Spatial resolution that effect to water level at Phnom Penh, 250m cause water levels at Phnom Penh slightly better than 1km. From inundation area and groundwater levels shows that effects of grid size shows that inundation area and groundwater of high resolution (250 m) is lower than low resolution (1 km).

ACKNOWLEDGEMENT

This study was supported by JASSO Scholarship and we acknowledge the generosity of Kaigan Laboratory.

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