II－25 Applicability of NDVI databases in Runoff simulations in the Mekong River basin

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1. Introduction

BTOPMC, Block wise use of TOPMODEL with Muskingum-Cunge flow routing method (Takeuchi et al., 1999), a physically based semi-distributed hydrological model was used to simulate hydrographs at five stations in the Mekong River basin with the unit time interval being 24 hours. Even though Human activities within a watershed play an important role in hydrological processes, hydrological models including BTOPMC are still not capable of incorporating human activities such as farming and land use changes. There are few fully distributed models, capable of handling land use changes with data demanding and yet to proof their suitability for large ungauged basins. NDVI (Normalized Difference Vegetation Difference) time series data obtained from global 1 km land use data sets were use to detect land use types and their respective NDVI values to discuss the applicability and the possible improvements of the BTOPMC model in runoff simulations in large scale basins. Differences in observed and simulated runoff and monthly average NDVI time series were used in the analysis.

2. Study Area

The 4,200-kilometre Mekong River (Figure 1), twelfth longest river in the world is the life-blood of Southeast Asia. Fed by melting snow on the Tibetan Himalayas and by monsoon rain, the river nourishes millions of lives from Southern China, Myanmar, Laos, Thailand, and Cambodia to the delta in Vietnam. As the river passes through these countries, regional scale watershed management plays an important role in sustainable water resources development. A sound hydrological model with capable of modeling land changes is very importance for river basin development.

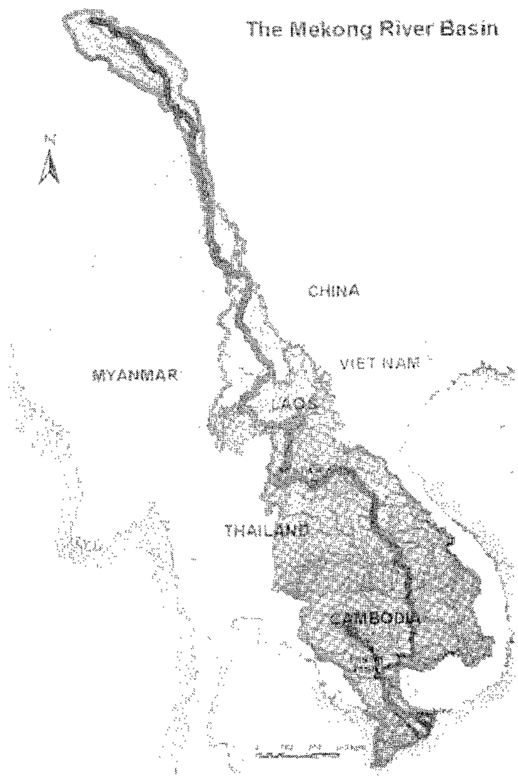

Figure 1. Study Area

3. Data set

Hydro-meteorological data sets were collected from Mekong River Commission (MRC) yearbooks and from NOAA National Climate data center CD- ROM. Daily runoffs of five gauged stations: Chiang Saen (189 000 km^2), Luang Prabang (268 000 km^2), Vientianei (299 000 km^2), Mukdahahn (391 000 km^2) and Pakase (545 000 km^2) were used to simulate the runoff.

Earth Resources Observation System (EROS) Data Center of the U.S. Geological Survey have developed 1-km resolution global land cover characteristics based on 1-km Advanced Very High Resolution Radiometer (AVHRR) data spanning April 1992 through March 1993. This data set was used for the NDVI exaction.

4. Results and Discussions

Runoff distribution was simulated from BTOPMC model developed in the Yamanashi University, Japan. The model was calibrated for 1987 and validated for 1993 and 1994. Results at Pakse discharge measuring station are shown in Figure 2. Figure 3 shows the variation of differences between simulated and observed runoff at Pakse. Other stations also show a similar pattern. Modeling incapability of human activities such as paddy cultivation and reservoir operation might be the possible reason for similar seasonal variation of error in runoff simulation. Generally, rainy season starts in May and continues until October. First paddy cultivation season starts at the beginning of May and harvesting is in the month of August. The other cultivation season is from October to January. From the preparation stage, until the middle of the farming season paddy fields need a large amount of water. Observed runoff values in the basin of high farming lands like Mekong are less than simulated runoffs during these seasons. As the water level is in its minimum at the end of dry season, reservoir-regulating authorities like to store water to their capacity in rainy season. Reservoir operational curves depend on rainfall and the purposes of reservoir such as flood control

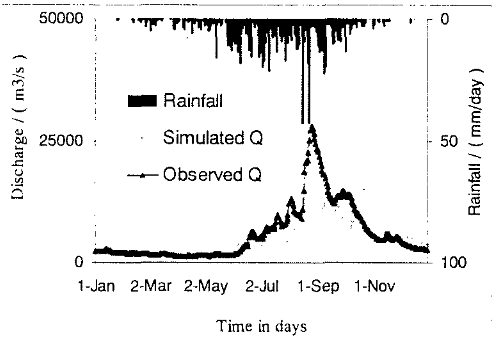

Figure 2: BTOPMC result at Pakse in 1987

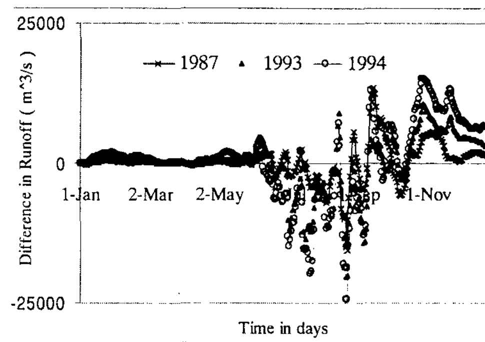

Figure 3: Difference in simulated and observed runoff Runoff at Pakse

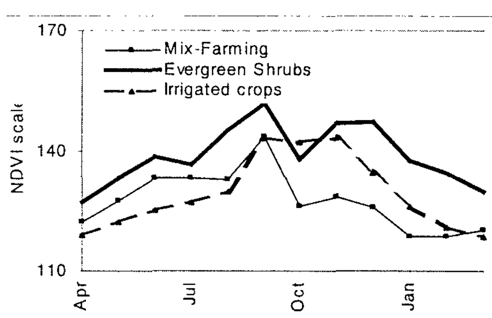

Figure 4: Variation of average (Pakse) NDVI for Different land use

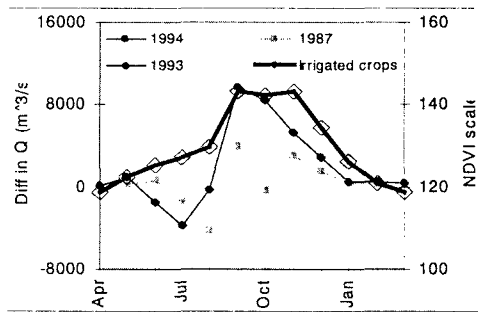

Figure 5: Variation of average NDVI for Irrigated crops and error in runoff simulation

Hydropower generation, water supply and irrigation. Early water releases from reservoirs and excess water release from paddy fields in July and August show large observed runoff than simulated. During the second cultivation season, rainfall is less and the farmers like to store water during October to December. This leads to lesser quantity of observed runoff than simulated

NDVI for different land uses derived from Biosphere-Atmosphere Transfer Scheme (BATS) (Dickinson and others, 1986) shows different variation throughout the year. Values referred to the Mekong River basin was exacted form the original database. The most down stream hydrograph generated in the study is at Pakse and NDVI in the Mekong River basin up to Pakse were used for detail analysis. Variation of average NDVI scale (100NDVI +110) for different land use types is shown in Figure 4. Though NDVI is high from August to November as expected in irrigated crops, mix forest and evergreen shrubs, it is shows comparatively low values in mix farming. There are three kinds of farming types in the region. One type shows almost constant NDVI variation throughout the year. The other two types have maximum values in September. Second farming type continues its NDVI similar variation before September where as the third one's indices decrease dramatically. Though both mix forest and evergreen shrubs shows local minimum values in October, irrigated crops show constant values from September to November. Soil water storage or flood inundation could be the possible reason for this kind of behavior.

Figure 5 shows the variation of difference in runoff and NDVI for irrigated crops throughout a year. Both time series have similar patterns. This concludes the improving accuracy with adding of NDVI components to the BTOPMC model.

5. Conclusion

Block-wise use of TOPMODEL with the Muskingum–Cunge flow routing method can be applied to simulate runoff in large basins and the results are acceptable. Although the BTOPMC model is capable of modeling changes in topography, it cannot model land use changes. Inclusion of additional model for land use or seasonal model calibrations from NDVI improves accuracy of runoff modeling.

6. References

1) Takeuchi, K., Tianqi, A. and Ishidaira, H., Introduction of block-wise of TOPMODEL and Muskingum – Cunge method for hydro-environmental simulation of large ungauged basins. Special Issue of Hydrological science Journal, Vol. 44, no 4, 1999.
2) Dickinson, R.E., Henderson-Sellers, A., Kennedy, P.J., and Wilson, M.F., 1986, Biosphere-atmosphere transfer scheme (BATS) for the NCAR community climate model: NCAR Technical Note NCAR/TN275+STR, Boulder, CO. 69 p