Development of a Distributed Water Circulation Model Assessed with Paddy Water Use in Mekong River Basin

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Water use in Monsoon Asia is characterized as large share of agricultural use, various types of paddy rice irrigation, coexistence of distinct dry and wet seasons and occurrence of flood and drought. However, the water cycle mechanism and the effects of its change on food production have not yet understood due to the lack of data on land use, climate and hydrological conditions. This study, therefore, paid attention to rice paddy fields having a influence on water circulation and food production in the Monsoon Asia. And a distributed water circulation model considered paddy water use was developed for the Mekong river basin.

In this model, cell size was set at 0.1 degree and whole area of the Mekong river basin was targeted. This model is composed of four sub-model: 1)Potential evapotranspiration (ET), 2)Cropping pattern and planting/harvesting area (Cropping model) , 3)Paddy water use, and 4)Runoff. The potential ET model calculates reference ET (ET_r) by the Penman-Monteith Method. The cropping model estimates planting commencement day, planting area and harvested area based on cropping pattern of each country and paddy type. At this sub-model, planting commencement day in the wet season crop and the floodwater-utilizing paddies varies according to precipitation. In addition, planting area is influenced by yield decrease area calculated from ET_r and actual ET (ET_a). The paddy water use model accounts the irrigation water amounts in consideration of the difference of irrigation facilities, relationship between water requirement and water intake capacity, and rain reservation on paddy area. ET_a is calculated from ET_r, ET coefficient of each land use (including planting or non-planting), and soil moisture in the root zone. The runoff model applies the concept of variable contributed area at each cell, and estimates outflow and soil moisture with water balance. Soil layers are divided into three layers: root zone, unsaturated zone, and saturated zone. Outflow is sent to downstream cell determined by the flow direction judgment. Furthermore, to reproduce return flow from underground to surface, two occurrence conditions for return flow are set: the soil moisture of underground is enough (groundwater level is greater than the potential soil moisture) and groundwater inflow (Q_{gin}) is greater than groundwater outflow (Q_{gout}). If these are satisfied, the difference (Q_{gin}-Q_{gout}) is added to surface flow. Moreover, to reproduce the divergence of river in the Mekong Delta (Bassac and Mekong rivers), the direction in the lower Mekong is corrected according to the actual river system.

Land use is expressed by the size ratios of irrigated paddies, rain-fed paddies, forest, upland and water. Moreover Rain-fed paddies are classified as three types: using only rainfall, using supplementary water and using floodwater. Irrigated paddies are also classified as six types based on the type of irrigation facilities: gravity irrigation, pumping irrigation, reservoir water supply, the colmatage system, tidal irrigation and groundwater use.

The developed model was applied to the Mekong river basin from 1999 through 2003, and various results such as cropping paddy area, ET_a, irrigated water depth, and surface flow were obtained. Since cropping paddy area is influenced by precipitation in each year, the planting commencement day of rainy season crop in 2000 (rainy year) was earlier than that of other years, and the harvested area was larger by controlling yield decrease caused along with water stress. The comparison between the estimated and observed river flows at Pakse shows fairly good results through 5 years. Moreover, comparing ET_a with the observed ET at an experimental paddy site from July through December in 2003, a high correlation was obtained (R^2=0.936).