湿潤熱帯流域の降雨流出氾濫現象とモデリング
Rainfall-Runoff-Inundation Processes and Modeling in a Humid Tropical River Basin

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Large-scale plantations of palm and acacia trees have caused 50 % reduction of natural forests in the 25 years between 1985 to 2009 in Sumatra, Indonesia. Deforestation of natural forest might have changed water cycle in the area including runoff and evapotranspiration, which may lead to possible changes in flood and drought conditions. Downstream parts of river basins in Sumatra spreads wetlands with rich ecosystems, though such environment have degraded due to land cover changes over the last few decades to agricultural areas. Drying the wetlands by drainage for rice cropping and other agricultures caused various issues including peatland fire and haze in surrounding regions. In addition to the land cover change, climate change may give significant impact on the hydrologic cycle in this region. Climate change in humid tropical region in South East Asia has been difficult to be predicted due to local atmospheric cycle. Furthermore, hydrologic process understandings and their representations by simulation models are the important scientific step toward adequate assessment of land cover and climate changes. Among various hydrologic processes, rainfall-runoff processes in tropical climate conditions characterized also by deep weathered soil layers have been poorly understood. Our study is conducted based on field investigation with respect to rainfall-runoff processes in the mountainous hillslope in Sumatra to understand the fundamental characteristics of rainfall-runoff in this region, and to represent the feature particularly with a thick soil layer, in our distributed hydrologic model. After the calibration and validation of the model at the river basin scale in the Batanghari River basin, we assess the impact of the climate change by inputting the rainfall.

Some findings from the field monitoring are summarized below. According to a simple cone penetration experiment, the soil depths in the hillslope were estimated to be about 1.5 ~ 4.5 meters. Furthermore, the soil sample experiment at surface, 30 cm and 60 cm depths showed that saturated hydraulic conductivities were as high as 7,200 mm/h while the volumetric water content maintain also high (0.45~0.50) with negative suction between 1~10 m. Such characteristics should be explained due to the aggregated soil in humid tropics. In our site, the foot of the slope (SK1) has thicker soil layer (4.5 m), while it is reduced to 1.5 m about 20 m upstream along the hillslope (SK3). Groundwater table exists at the depths of about 3 ~ 4 m depth consistently at SK1 (bottom) and SK2 (middle) and the groundwater table responses rapidly to rainfall. With the high saturated hydraulic conductivity and high infiltration rate, especially in the natural forest area, we conceptualize the rainfall-runoff in this region is dominated by fairly quick vertical infiltration into the thick soil layer and the recharge to the groundwater table. Based on the above process understandings, we represent the process in the Rainfall-Runoff-Inundation (RRI) model to the entire Batanghari River basin to simulate streamflow at the river basin scale.

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