論 文 内 容 の 要 旨

森林科学　専攻

平成１８年度博士課程　入学

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論文題目　Analysis of water and carbon cycle in an undisturbed tropical rainforest using Biome-BGC model
（Biome-BGC モデルを用いた熱帯雨林の水・炭素収支の解析）

Deforestation of tropical forests and intensive agriculture expansion are some of the major contribution factors driven by human activities to the changes in the global environment. The effect of human activities on Southeast Asia tropical rainforest has raised concerns as it is not well researched for its role in sustaining the global climatic system as compare to other rainforest biomes in Central America and Africa. Using measured micro-meteorological data and a complex process based model, the Biome-BGC model, we aim to combine both conventional method and modelling method to bring possible estimates of water budget and carbon budget especially for Asian tropical rainforests. The study site is located in a natural lowland evergreen broadleaf tropical rainforest in Sarawak, Malaysia Borneo. The Lambir Hills national park is designated and protected under the Sarawak

Government as a totally protected area.

In chapter 1, we summarized the role of tropical rainforest in global water cycle and carbon cycle. The importance function of old growth forests in absorbing carbon dioxide and also acts as global carbon sink. We also look into the possible major land use changes taken placed in the study area in general especially in the Malaysia Borneo. The impact of major land use changes and the growing population in depleting the natural resources in the country especially through deforestation and monoculture agriculture plantation replacing old growth forests and secondary forests. In our research method, we are integrating using ecological models with observational data to provide another observation option as opposed to the normal long term field observation. Our focus is also to evaluate the potential use of Biome-BGC model to simulate long term carbon and water budget and compare the model outputs with simpler evaporatranspiration model like Penman-Monteith model or the Big-Leaf model.

In Chapter 2, review on land laws and forest classification in Malaysia shows how the laws started during the British colonial time had slowly eroded the native's rights over their land. By giving more control to the State government to classify and turning permanent tropical forest land for agricultural expansion.

In Chapter 3, the site location, characteristic of the undisturbed lowland evergreen forest, and the type of micro-meteorological measurements carried out at the study site were described. The climate with mean annual rainfall around 2700mm and mean air temperature remains around 27℃ throughout the years. It is shows small seasonal variation in temperature and rainfall except during extreme meteorological phenomena like El-Nino. A review of past water budget estimates

were also presented. It is important as it acts as the 'check and balance' on determining the rationality of the model outputs. A brief description of the Biome-BGC model was also presented together with the model design on the mechanisms that control CO_2 and H_zO fluxes.

In Chapter 4, the Biome-BGC model was first tested using one year micro-meteorological data collected for the period from July 2001 to June 2002. In our study, LAI is used as the principal independent variable used to determine the model compatibility to fit the observation data of the study site. We tested the effect of each individual parameter separately by increasing and reducing a certain percentage of the default value. We focussed on the simulated results for LAI, ET and GPP. By changing the eco-physiological parameters for the original EBF to our modified parameterization of LHNP, our modelled LAI was estimated 5.29m^2m^{-2}. By increasing twice the daily value of VPD and using the modified eco-physiological parameter, the Biome-BGC model estimated for interception evaporation, Ewet = 195.57mm, and the total of transpiration, Edry and soil evaporation, Esoil was estimated at 947.88mm. Our annual modelled ET shows a slightly low amount of 1145.47 mm compared to observational annual ET equalled to 1401.1mm. It also shows a consistent pattern of seasonality with observed ET. Modelled estimate GPP shows slightly lower at 24.5 $tCha^{-1}yr^{-1}$ compare to observed GPP reported in Amazon and Lambir. Modelled NEP was estimated positive at 0.68 $tCha^{-1}year^{-1}$ and concluded that the forests at the study site are CO^2 sinks and have reached maturity point.

In Chapter 5, we continue to use our modified parameter in a five year observation micro-meteorological data. Our average mean Ewet values for five year was

235mm/year. It is slightly more than the observed Ewet reported in Manfroi (2006) and Kume (2008, in personal communication). Kumagai et al. (2005) computed using Priestly and Taylor (PT) equation that total transpiration and soil evaporation was 1193.1mm for the study site. The Biome-BGC model estimated Edry + Esoil for five years starting with year 2000 ranged from the lowest 802.32 in year 2003 and the highest in year 2004 with estimate of 1128.78. And the mean average for Edry + Esoil for total five years was estimated 1000mm/year. However, the seasonality of transpiration as shown in Fig. 5.3 can explained the relationship between vapour pressure deficit (VPD) and transpiration. After modifying the parameters that control the Biome-BGC model, it shows that the model does produce good estimate especially for the water fluxes elements.

Our average annual ET for five years totalled to 1234mm/year and it is in ranged with other evapotranspiration studies conducted in lowland tropical rainforest. It mentioned that ET ranged between 1124 – 2138 mm with mean 1476 mm and median 1400 mm. Kume (2008) estimated the annual ET and Ewet over 5 years were estimated as 1064mm/year and 210mm/ year.

Continued rapid forest loss from the timber estate indicates that Southeast Asian government in general no longer consider production forestry in natural forests to be of major economic importance (Dennis, R.A. et al 2008) In the end, we hope our model could be used as an important management tool for policy makers, climatologists, forest scientists, social scientists, government officials, foreign and local investors in agriculture plantation and renewable energies in deepening their understanding on the importance of the Southeast Asia tropical biomes in tackling global climatic changes and also the importance of sustainable forest management.