論 文 の 内 容 の 要 旨

論文題目　Empirical bio-geophysical modeling of CO_2 budget from tropical peat lands in Indonesia
（生物地理学的経験式を用いたインドネシアの泥炭地における二酸化炭素収支の推定）

氏　名　朴 慧美

Global carbon dioxide (CO2) budget estimation is required for a sustainable development of the Earth. Despite peatland covers only 3% of global land area, the carbon amounts are one-third of global soil organic carbon. Peat land is one of the largest CO2 emission source potentially due to the fires and decomposition. Tropical region has 10% of global peat soil. The organic matter of tropical peat forest is reported up to 70 PgC, which accounts for 20% of global peat soil carbon and 2% of global soil carbon. The water supply is the most important factor to form the peat soil because of the abundant ground water is needed to make reduction condition, and actions of microbes are not available under reduction condition. However, wide area of tropical peat lands is disturbed by human made drainage canal and ground water table decreased drastically by human activity for converting to agricultural use, timber transport or illegal logging. The peat land around of drainage canal may have lower ground water table and they would be decomposed more than another saturated area. Ground water level declining is pointed as big problem for peat decomposition, however, there is no many studies to assessment of drainage canal effect. For that reason, this study focused on the human effect such as drainage in peat land hydrology. Especially, peat lands of Indonesia have been disturbed widely by deforestation and oxidation through government policy, for instance Mega Rice Project 1999. Moreover, burning event on peat forest is severe problem because of forest
is the biggest carbon absorber and the peat soil stores large amount of carbon from dead plants.

From early 2000's, Wetland international and some researchers tried to estimate carbon emission from tropical peat lands by using inventory-based estimation that method of constant CO2 emission value multiplied to area of peat. However, those estimation could not be validated because of lack of in-situ observation data. Fortunately, Hirano et al. (2007) reported flux tower observation in Palankaraya peat forest which established

in 2001 by Hokkaido university of Japan. The approach of flux tower observation is helpful for validation those models and monitoring sustainable carbon budget from 2002 to 2006. This study also used result of flux tower on Palangkaraya for validation of net biome production and gross primary production.

The objective of this study is to reveal Carbon budget in tropical peat lands in Indonesia by using satellite-based data and empirical bio-geophysical modeling, through respiration estimation with equation of relationship between soil respiration or ecosystem respiration and ground water table, and every dataset of components for equation of res- piration concentrated to satellite-based data. Secondly, the drainage as a human effect is considered at this time with water canal detection by using microwave satellite image of ALOS PALSAR in order to estimate artificial decomposition of peat organic matter.

For estimating CO2 emission from peatlands in Indonesia, ground water table was estimated by satellite based precipitation and land surface temperature by modified Keetch- Byram Drought Index (mKBDI). Ground water table data is provided in resolution of 4km daily from 2002 to 2012. Validation of ground water table was done in Jambi province peat lands on Sumatra and it was successful especially in dry season. From this in-situ measurement, minimum GWT was lower than 1.6m in dry season. The temporal dynam- ics of carbon budget could be described in this study by remote sensing data sets. The CO2 emission is represented by Net Biome Production (NBP) which can be calculated

withthisequation: NBP=ER-GPP+FE,whereERisecosystemrespiration,andGPPis gross primary productivity. FE means fire emission driven by MOD14 hotspot. Soil respiration is included in ecosystem respiration, in peat lands, soil respiration is the biggest factor for ecosystem respiration. GPP describes an amount of photosynthesis of plants by using NDVI, PAR and light use efficiency of MODIS, however, in tropical region, MODIS GPP product shows underestimation. This study modified GPP by calibrating with flux tower observation. After complete estimation of ER and GPP, and then NBP can be calculated. NBP on this study was validated by previous result of flux tower and some publications.

For estimating drainage effect, microwave image of ALOS PALSAR (50m of spatial resolution) was used because it can detect difference of surface roughness on the pixels of drainage canal. Canny edge detection method was applied to these images. Accordingly, ground water table of Indonesian peat lands was re-calculated by this drainage canal detection result and respirations are re-estimated also.

In Indonesian peat lands, there are some artificial impacts to CO2 emission from not

only drainages but also fire events. Finally, this study revealed vulnerability against fire of Indonesian peat lands by using analysis of relationship between location of fire and road. Vulnerability against fire is revealed by road distribution and detection of fire location. The reasons of fire are dryness of peat or human activity. This study decided vulnerability at near from road is higher than inner peat area because human accessibility is considered as a possibility of fire. Finally, artificial impact to fire event was revealed. If fire was occurred under the close location from road, it is supposed to be a human made fire. As the result, fire was occurred near from road, however, even though there is no road but fire events were detected since drainage canal. Therefore, we considered that the drainage canal has been used as a tool of access into the peat lands by human.

As the result, Net biome production (NBP) was overestimated due to overestimation of respiration and underestimation of gross primary production. NBP as quantity of natural CO2 emission is affected by climatic change such as high temperature in El Nin˜o, low temperature in La Nin˜a clearly. Specially, this study concerned to human impact for CO2 emission by drainage and fire event in Indonesia. Only non-forested area, distributed in area of 5.89×1010(m2)was used for detection of drainage canal. Detected drainage canal area was 1.93×1010(m2). The affected area of drainage canal was 40,425km2, about 32.7% of non-forested area. Drainage canal is a factor for modification of lowering GWT, so respiration that a result of formula by GWT was increased. Drainage effect to total emission part, which is the sum of ecosystem respiration and fire emission, is calculated as 10% and this number is comparable with fire emission that 3.12% of total emission part. Fire emission from Indonesian peat land was changed with climatic factors clearly. Furthermore, fire occurrence is deeply related to distance from road for easy human accessibility. The closer to road stands for the more fire occurrence. Despite fire was detected until 26km from road however, over 85% of fire event was occurred in area of 10km and 50% is detected in 3km. From these approaches, it was implied that artificial impacts are influential for enhancing carbon emission. Decomposition by drainage and fire emission changed peat lands from carbon sink to carbon source. For reducing CO2 emission from peat lands of Indonesia, not only rewetting ground water table but also control of human disturbance are important. Thus, fire vulnerability analysis with road distribution and drainage canal can be useful data on reducing CO2 emission of tropical peat lands. Satellite based empirical modeling was successful to estimate CO2 emission from entire Indonesian tropical peat lands.