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Author(s)	Marpaung, Fiolenta
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学 位 論 文 内 容 の 要 旨

博士の専攻分野名称：博士（農学）　　氏名：Fiolenta Marpaung

学位論文題名

Quantitative evaluation of radiation change and vegetation recovery during and after fires in tropical peatland

（熱帯泥炭地における火災による放射環境の変化と火災後の植生回復の定量的評価）

In Southeast Asia, a huge amount of peat has accumulated under peat swamp forest. However, large-scale fires because of land clearing under a dry condition have rapidly devastated these peatlands. El Niño events prolong the dry season and raise the risk of large-scale peat fires by lowering groundwater levels (GWL). Through the fires, biomass and surface peat are burnt, and consequently dense smoke or aerosol covers the ground. As a result, solar radiation itself and its ground reflectance are changed. The change of solar radiation both in quantity and quality affects vegetation photosynthesis. In addition, the change of reflection properties can be used to estimate the vegetation damage and recovery, respectively, during and after fires. However, knowledge about the effects of peat fires on dynamical surface radiation change is quite limited.

The objectives are to quantitatively evaluate solar radiation change and vegetation recovery during and after the peat fire of 2009 in tropical peatland using long-term field data measured for more than 10 years (2004-2014) in Central Kalimantan, Indonesia.

1. Environmental dependence and seasonal variation of diffuse radiation in tropical peatland

Daily diffuse fraction (R_d/R_g) of solar radiation was significantly related to the clearness index (R_g/R_o) via a linear threshold model. Under the clear sky, R_d/R_g was larger in tropical peatland with a humid climate than in Australia. Using the model, long-term variation in R_d/R_g was estimated from global solar radiation (R_g). As a result, R_d/R_g showed a seasonal variation with its minimum of 0.51 in June (the transition

between the wet and dry seasons) and its maximum of 0.68 in October (the late dry season) on a monthly basis. The decreasing pattern in the transition season corresponded to decreasing precipitation due to fewer clouds. In contrast, the increasing pattern during the dry season was due to shading by smoke emitted through burning biomass and peat fires. In particular, during the El Niño droughts in 2002, 2006 and 2009, the monthly mean R_d/R_g rose above 0.72, because the ground was densely covered with smoke from large-scale fires.

2. Spectral vegetation dynamics and vegetation recovery in a fire-disturbed ex-tropical peat swamp forest

Vegetation indices (VIs: NDVI and EVI2) and leaf area index (LAI) were derived from spectral reflectance data measured using satellite (MODIS) or tower radiometers to monitor vegetation recovery after fires. To calculate VIs and LAI, the R_g has to be separated into photosynthetically active radiation (PAR) and near infrared radiation (NIR). The ratio of PAR to R_g tended to increase with the solar zenith angle. In addition, the PAR ratio was higher in overcast conditions than in clear sky conditions. These results improved a model to estimate surface reflectance. Furthermore, it was found that water on the ground changed surface reflectance and decreased VIs. After exclusion of VIs under the conditions of dense smoke (high R_d/R_g) and flooding, tower-based broadband VIs showed a liner relationship with MODIS VIs, but interannual variation in VIs after the 2009 fire was smaller than expected. LAI varied seasonally; it rapidly decreased as the ground was studded with water (GWL $\geq$ 0 m) and sharply increased as GWL lowered underground. In addition, LAI showed interannual increase after the fire in accordance with vegetation recovery. However, peat fire changed soil bulk density and hence increased NIR reflectance, which affects VIs. Therefore, for long-term monitoring during before and after fires, further studies are needed to fill the gap caused by the change in soil properties in this peat ecosystem.