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Comparison of LAI estimation based vegetation index and MODIS LAI for gross primary productivity estimation, deciduous broadleaf forest in Japan

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Leaf area index (LAI) is the main input parameter in the ecological models, which defined as one-sided green leaf area per unit ground area (Myneni et al., 1988). It is considered as key variable for scaling up forest productivity from leaf to large scale. In several ecological models, LAI is used to determine the solar radiation absorption for gross primary productivity (GPP) estimation. GPP is the assimilation of carbon absorption by plants. It can be indicated the carbon status on the biosphere which is to understand global carbon cycle process.

Among ecological models, Spatial 3-PG (Physiological Principles Prediction Growth in Spatial version) is selected to apply for GPP estimation. It is extended version of 3-PG (Landsberg and Waring, 1997), which is the original model, from one dimension to two dimensions by coupled with satellite images. The main inputs are meteorological data, site factors, and species-specific parameters with the additional satellite images. The use of the satellite image allows estimating LAI. The LAI data from the satellite image are up to date and close to real conditions on the ground. Subsequently, GPP is calculated by converting absorbed photosynthetically active radiation (APAR) to GPP using canopy quantum efficiency (αC). Canopy quantum efficiency is constrained by environmental conditions.

In this study, the satellite images are used to examine the relationship between LAI and vegetation index (VI) (LAI–VI relationship), which is added to the model. Two VIs are commonly used to estimate LAI as Normalised Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI). MODIS 8 days composite data are used to calculate in terms of each VI. The primary study site is located in central Japan, Takayama. The main vegetation type is deciduous broadleaf forest. In situ LAI data at Takayama collected from 2005 to 2006 were compared with the VIs data, which are extracted from the one pixel corresponding to the location of study site on the satellite image. The relationship of LAI-VI is separated into 2 periods as growing season and falling season. Among VIs, EVI shows the highest correlation with LAI, with R2 equal to 0.88. Then, LAI-EVI is chosen for GPP estimation in the Spatial 3-PG model.

Moreover, MODIS LAI 8 days composite are used as another input parameter instead of LAI estimation based EVI in the model. The result of GPP estimation from LAI-EVI based are compared with MODIS LAI based. As well, in situ GPP are used to validate with both results as well as MODIS GPP. These comparisons can perform the errors of MODIS products, when it is used to apply to the ecological model. The results showed that GPP based MODIS LAI and MODIS GPP give the overestimated value more than GPP based LAI-EVI relationship. Since the algorithm of MODIS LAI is used a lookup table method, based on the six canopy types, which cannot cover in more details in the local scale. As well, MODIS LAI gives high LAI value because it includes LAI from the vegetation floor. However, the satellite images still have the potential to support GPP estimation at certain levels of accuracy for quantitative measurement.