Estimation of leaf area index in the mountainous forest of Japan by application of a simple model on the Landsat Operational Land Imager imagery

*Irina Melnikova[1], Yoshio Awaya[2], Taku Saitoh[2], Hiroyuki Muraoka[2], Takahiro Sasai[1]

1. Department of Geophysics, Graduate School of Science, Tohoku University, 2. River Basin Research Center, Gifu University

Leaf area index (LAI), defined as a maximum projected leaf area per unit ground surface, is the indicator of terrestrial ecosystem structure, which integrates ecosystem functions such as photosynthesis, transpiration, and autotrophic respiration from the scale of an individual leaf to total tree and canopy scales. In this study, we estimate the spatial and temporal variations of LAI over a forested catchment in the Daihachiga River Basin (Gifu, Japan) in a 30-m resolution (Melnikova et al., 2018). For that, we applied a simple semi-empirical model, based on the Monsi-Saeki light attenuation theory (Awaya et al., 2007), on the four Landsat Operational Land Imager (OLI) images of spring and mid-summer. We validated the model performance at four study plots of deciduous broadleaved, deciduous coniferous and evergreen coniferous forests.

The estimated spatial LAI variation in spring indicated an altitudinal gradient in the leaf expansion timing, whereas the LAI variation in summer suggested an altitudinal gradient in the yearly maximum forest foliage density. The maximum forest LAI was estimated to be 5.5 ±0.2 in the deciduous broadleaved and 5.3 ±0.2 in evergreen coniferous forest areas. The temperature was among the major factors that largely contributed to the spatial LAI variations.
The use of the Landsat OLI imagery allowed a spatially detailed LAI representation. The imagery pre-processing included an elevation-dependent dark object subtraction (Awaya et al., 2016), which efficiently reduced the vertically non-homogeneous atmospheric effects, and the Minnaert correction, which diminished the slope shadows, associated with the steep topography and the 1000-m elevation gradient in the mountains. The benefits of the applied LAI model included the simplicity, need for only a few input parameters and adaptability for various forest ecosystems. This study demonstrated the importance of an accurate estimation of fine-resolution spatial LAI variations for ecological studies in the areas of complex terrain.

Keywords: LAI, Landsat OLI, phenology, complex terrain, forest structure, Monsi-Saeki theory

