Estimation of broad-leaved canopy growth in the urban forested area using multi-temporal airborne LiDAR datasets

Abstract

Inter-annual canopy growth is one of the key indicators for assessing forest conditions, but the measurements require laborious field surveys. Up-to-date LiDAR remote sensing provides sufficient three-dimensional morphological information of the ground to monitor canopy heights on a broad scale. Thus, we attempted to use multi-temporal airborne LiDAR datasets in the estimation of vertical canopy growth, across various types of broad-leaved trees in a large urban park.

The growth of broad-leaved canopies in the EXPO '70 urban forest in Osaka, Japan was assessed with 19 plots at the stand level and 39 selected trees at the individual-tree level. Airborne LiDAR campaigns repeatedly observed the park in the summers of 2004, 2008, and 2010. We acquired canopy height models (CHMs) for each year from the height values of the uppermost laser returns at every 0.5 m grid. The annual canopy growth was calculated by the differences in CHMs and validated with the annual changes in field-measured basal areas and tree heights.

LiDAR estimations revealed that the average annual canopy growth from 2004 to 2010 was 0.26 ± 0.11 m m^{-2} yr^{-1} at the plot level and 0.26 ± 0.10 m m^{-2} yr^{-1} at the individual-tree level. This result showed that growing trends were consistent at different scales through 2004 to 2010 despite uncertainty in estimating short-term growth for small crown areas at the individual-tree level. This LiDAR-estimated canopy growth shows a moderate relation to field-measured increase of basal areas and average heights. The estimation uncertainties seem to result from the complex canopy structure and irregular crown shape of broad-leaved trees. Challenges still remain on how to incorporate the growth of understory trees, growth in the lateral direction, and gap dynamics inside the canopy, particularly in applying multi-temporal LiDAR datasets to the large-scale growth assessment.