Synergistic use of Landsat 8 OLI image and airborne LiDAR data for aboveground biomass estimation in tropical lowland rainforests

ABSTRACT

Developing a robust and cost-effective method for accurately estimating tropical forest's carbon pool over large area is a fundamental requirement for the implementation of Reducing Emissions from Deforestation and forest Degradation (REDD+). This study aims at examining the independent and combined use of airborne LiDAR and Landsat 8 Operational Land Imager (OLI) data to accurately estimate the above-ground biomass (AGB) of primary tropical rainforests in Sabah, Malaysia. Thirty field plots were established in three types of lowland rainforests: alluvial, sandstone hill and heath forests that represent a wide range of AGB density and stand structure. We derived the height percentile and laser penetration variables from the airborne LiDAR and calculated the vegetation indices, tasseled cap transformation values, and the texture measures from Landsat 8 OLI data. We found that there are moderate correlations between the AGB and laser penetration variables from airborne LiDAR data ($r = -0.411$ to -0.790). For Landsat 8 OLI data, the 6 vegetation indices and the 46 texture measures also significantly correlated with the AGB ($r = 0.366–0.519$). Stepwise multiple regression analysis was performed to establish the estimation models for independent and combined use of airborne LiDAR and Landsat 8 OLI data. The results showed that the model based on a combination of the two remote sensing data achieved the highest accuracy (R2 adj = 0.81, RMSE = 17.36%) whereas the models using Landsat 8 OLI data airborne LiDAR data independently obtained the moderate accuracy (R2 adj = 0.52, RMSE = 24.22% and R2 adj = 0.63, RMSE = 25.25%, respectively). Our study indicated that texture measures from Landsat 8 OLI data provided useful information for AGB estimation and synergistic use of Landsat 8 OLI and airborne LiDAR data could improve the AGB estimation of primary tropical rainforest.