（千葉大学審査学位論文）

FOREST TYPES MAPPING AND BIOMASS ESTIMATION IN CENTRAL HIGHTLANDS OF VIET NAM USING MICROWAVE AND OPTICAL REMOTE SENSING

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ABSTRACT

Forest biomass is essential for increasing our understanding of the terrestrial carbon cycle and promoting conservation and sustainable management of the forest resources. Satellite remote sensing has become a major source of data to estimate biomass and carbon stocks.

This research was conducted in Yok Don National Park in the Central Highlands of Vietnam. Altogether 110 sample plots were established in the field. The land cover map of year 2015 in the study area was prepared using the supervised classification method along with the geo-location points belonging to major land cover classes: evergreen broadleaf forest, deciduous broadleaf forest, water bodies, and other land cover types. It provided 89.12% overall accuracy. Major land cover classes in the study area were deciduous broadleaf forest (76.54%) and evergreen broadleaf forest (22.14%). The potential of the ALOS-2 SAR data for the estimation of tropical forest structural characteristics (diameter, height), and biomass was assessed with the support of forest inventory data. The effect of polarization and seasonality of the SAR data on the estimation of forest biomass was analyzed. Furthermore, to improve the accuracy of forest biomass estimates, combination of the ALOS-2 SAR and Landsat-8 data was explored. Multiple linear regression method was used for combining the different parameters. The coefficient of determination (R^2) and root mean square error (RMSE) were used as the metrics for evaluating the relationships.

The dry season backscattering intensity of the HH and HV polarizations was highly sensitive to the biomass than the rainy season backscattering intensity. The higher relationship between the dry season HV polarization and biomass ($R^2 = 0.57$, RMSE = 50.49 $Mg{\cdot}ha^{-1}$) was obtained. However, the relationship between the rainy season HV polarization and biomass was relatively lower ($R^2 = 0.34$, RMSE = 54.38 $Mg{\cdot}ha^{-1}$) than the dry season. This analysis suggests that dry season SAR data is more important for estimating the biomass than the rainy season data. The $\sigma°_{forest}$ could estimate 64% of the variability in the biomass ($R^2 = 0.64$, RMSE = 48.04

Mg•ha^{-1}) which better than the estimates by rainy season NDVI (R^2 = 0.43, RMSE = 60.45 Mg•ha^{-1}). This study also analyzed multiple linear regression between the biomass and two independent variables of the SAR data (HV and HH polarizations); the result was R^2 = 0.57, RMSE = 52.51 Mg•ha^{-1}. However, the combination of eight textures of SAR and rainy season NDVI xi provided better performance (R^2 = 0.62, RMSE = 49.36 Mg•ha^{-1}) than the rainy season NDVI alone. Though the SAR data only (HV and SAR textures) could explain 66% of the variation in the biomass (R^2 = 0.66, RMSE = 46.69 Mg•ha^{-1}), further addition of the rainy season NDVI improved the estimates (R^2 = 0.73, RMSE = 41.60 Mg•ha^{-1}). Ultimately, the combination of $\sigma°_{forest}$, eight SAR textures, and rainy season NDVI provided the highest performance (R^2 = 0.75, RMSE = 35.88 Mg•ha^{-1}). The best performed model was validated with R^2 = 0.74 and RMSE = 35.88 Mg•ha^{-1}.

The strong dependence of the biomass estimates with the season of satellite data acquisition confirmed that the choice of right time data is very important for improving the satellite based estimates of the biomass. The combination of SAR data and optical data resulted the best estimates of the forest biomass. The validation results showed that 74% of the variation of biomass could be explained by the best model. The best validated model was used to produce an up-to-date biomass map of year 2015 in study area. The results from the research are expected to contribute to the monitoring of forest carbon in Vietnam and other countries as well.