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Machine learning based estimation of aboveground biomass in subalpine forests using Landsat 8 OLI and Sentinel-2B images in Jiuzhaigou National Nature Reserve, Eastern Tibet Plateau

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Although forests cover about one third of global land surface, forests act as important biophysical, biogeochemical, hydrological, economic and cultural roles in the Earth systems. Forests contribute up to 75% of terrestrial gross primary production and store more carbon in forest biomass and soil compared to the atmosphere. Forest aboveground biomass (AGB) plays a crucial role in regional and global ecological balance. However, due to the difficulties in measuring forest biomass in the field at regional scales, a quantitative estimation with high accuracy of forest AGB by linking remote sensing is still a challenge, particularly in mountainous region. Thus, we combined the Landsat 8 OLI and Sentinel-2B data to estimate subalpine forest AGB using linear regression (LR), and two machine learning approaches - random forest (RF) and extreme gradient boosting (XGBoost), with the linkage of field observations in Jiuzhaigou National Nature Reserve, Eastern Tibet Plateau. A 10-fold cross validation (CV) method was used to evaluate the model accuracy, and then the proximity between the predicted value and the actual value was compared. The model efficiency (pseudo R^2) and root mean square error (RMSE) were used as the accuracy evaluation criteria. Based on 54 field observations, results showed that mean forest AGB was 180.6 Mg $ha^{-1}$with a strong spatial variability from 61.7 to 475.1 Mg ha^{-1}. AGB varied significantly among forest types that AGB in coniferous forests was significantly higher than coniferous mixed forests and broad-leaved forests. Landsat 8 OLI and Sentinel-2B imagery were successfully applied to estimate AGB separately or combined. Integrating the Landsat 8 OLI and Sentinel-2B imagery significantly improved model efficiency for different modelling approaches. For the regression algorithms, machine learning method outperformed the linear regression. Among LR, RF and XGBoost approaches, XGBoost performed best with a model efficiency (R^2) of 0.71 and root mean square error values of 46 Mg ha^{-1} and subsequently used for spatial modelling. Modelled results indicated a strong spatial variability in AGB, with a total 6.6×10^6 Mg across the study area. AGB distribution in the study area had obvious spatial characteristics, which was closely related to the elevation. It was mainly concentrated in the north and central areas, while in the southern region the AGB was relatively low, which was contrary to the trend of the elevation variation in the study area where the terrain was high in the south and low in the north. Our study highlighted a

potential way to improve the estimate accuracy of forest AGB in mountainous region by integrating the Landsat 8 OLI and Sentinel-2B data using machine learning algorithms.