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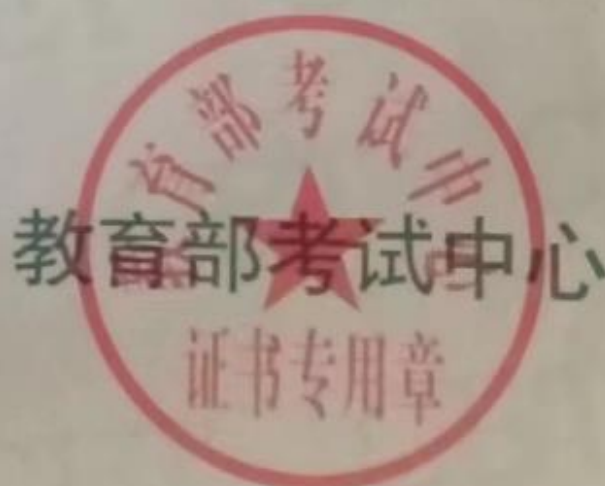
Article

Estimation of Quercus Biomass in Shangri-La Based on GEDI Spaceborne Lidar Data

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Abstract: Accurately estimating forest biomass based on spaceborne lidar on a county scale is challenging due to the incomplete coverage of spaceborne lidar data. Therefore, this research aims to interpolate GEDI spots and explore the feasibility of approaches to improving Quercus forest biomass estimation accuracy in the alpine mountains of Yunnan Province, China. This paper uses GEDI data as the main information source and a typical mountainous area in Shangri-La, northwestern Yunnan Province, China, as the study area. Based on the pre-processing of light spots. A total of 38 parameters were extracted from the canopy and vertical profiles of 1307 light spots in the study area, and the polygon data of the whole study area were obtained from the light spot data through Kriging interpolation. Multiple linear regression, support vector regression, and random forest were used to establish biomass models. The results showed that the optimal model is selected using the semi-variance function for the Kriging interpolation of each parameter of GEDI spot, the optimal model of modis_nonvegetated is a linear model, and the optimal model for rv, sensitivity, and modis_treecover is the exponential model. Analysis of the correlation between 39 parameters extracted from GEDI L2B and three topographic factors with oak biomass showed that sensitivity had a highly significant positive correlation ($p < 0.01$) with Quercus biomass, followed by a significant negative correlation ($p < 0.05$) with aspect and modis_nonvegation. After variable selection, the estimation model of Quercus biomass established using random forest had $R^2 = 0.91$, RMSE = 19.76 t/hm^2, and the estimation accuracy was better than that of multiple linear regression and support vector regression. The estimated total biomass of Quercus in the study area was mainly distributed between 26.48 and 257.63 t/hm^2, with an average value of 114.33 t/hm^2 and a total biomass of about 1.26×10^7 t/hm^2. This study obtained spatial consecutive information using Kriging interpolation. It provided a new research direction for estimating other forest structural parameters using GEDI data.

Keywords: spaceborne lidar; GEDI; biomass; inversion; Quercus

1. Introduction

Forests are called the lungs of the earth, and are an important part of the terrestrial ecosystem [1]. They also sustain 77% of the vegetation carbon pools and 39% of the soil carbon pools. Forest biomass is one of the essential carbon pools, the significant volume of which exerts long-term and extensive influence on carbon balance [2]. Meanwhile, forest biomass is a significant index used to assess forest quality and forest ecosystem function services. It can directly measure forest carbon sequestration capacity [3]. Therefore, accurate estimation of forest aboveground biomass (AGB) on a large scale is of great significance for mastering the carbon cycle mechanism and carbon storage change law of terrestrial ecosystem, exploring its response to global climate change, formulating carbon emission policy and relieving global warming [4]. Traditional methods for measuring biomass include direct measurement and the tree volume model estimation method. Although it

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Carbon Storage Estimation of *Quercus aquifolioides* Based on GEDI Spaceborne LiDAR Data and Landsat 9 Images in Shangri-La

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Abstract: The assessment of forest carbon storage plays a crucial role in forest management and ecosystem exploration, enabling the evaluation of forest quality, resources, carbon cycle and management. The Global Ecosystem Dynamics Investigation (GEDI) satellite provides a means to accurately measure these various forest vertical structure parameters by penetrating the forest canopy. However, the distribution of the footprint along the orbit track is heterogeneous and discontinuous, preventing the acquisition of spatially distributed carbon storage formation at the county level. Consequently, this study integrated GEDI and Landsat 9 data to estimate *Quercus aquifolioides* carbon storage in Shangri-La. By applying the Kriging interpolation to previously pretreated footprints, surface information from the GEDI L2B footprints was obtained. At the same time, Landsat 9 vegetation indices and band reflectance were extracted to analyze the correlation with the carbon storage of *Quercus aquifolioides* samples. Then, three methods (support vector machine, bagging, and random forest) were used to create a carbon storage estimation model for Shangri-La. The research results showed that (1) among the models for the selection of GEDI footprint parameters based on semi-variance, the optimal model of the digital_elevation_model was the spherical model, while the best model of percentage tree cover from the MODIS data (modis_treecover) and the foliage height diversity index (fhd_normal) was the exponential model. (2) Analyzing the thirty-three extracted independent variable factors correlated with the carbon storage of *Quercus aquifolioides* showed that the top five variables with the highest correlation were digital_elevation_model, modis_treecover, fhd_normal, DEM, and band 1 (B1). (3) After variable selection, the $R^2 = 0.82$ and RMSE = 11.92 t/hm^2 values of the *Quercus aquifolioides* carbon storage estimation model established via random forest were obtained, and its evaluation precision was superior to that of the support vector machine method and bagging regression. The carbon storage of *Quercus aquifolioides* was primarily in the range of 8.22~94.63 t/hm^2, and the mean value was 42.44 t/hm^2, while the total carbon storage was about 5,374,137.62 t. The findings from this paper illustrated the feasibility of obtaining carbon storage data on a county scale by combining GEDI LiDAR data with Landsat 9 optical data. The results also suggested a new perspective for combining GEDI L2B data with other remote sensing images to estimate other forest structure parameters.

Keywords: GEDI; LiDAR; Landsat 9; carbon storage; inversion

1. Introduction

The global forest area, although occupying only 1/3 of the terrestrial area, plays a crucial role in carbon storage within terrestrial ecosystems. Forest vegetation alone accounts for half of the terrestrial carbon pool [1] and stores 60% of the carbon ecosystem. Thus, forest land acts as the largest "carbon storage pool" and the most efficient "carbon