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Aboveground Biomass Retrieval in Tropical and Boreal Forests Using L-Band Airborne Polarimetric Observations

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Abstract: Forests play a crucial part in regulating global climate change since their aboveground biomass (AGB) relates to the carbon cycle, and its changes affect the main carbon pools. At present, the most suitable available SAR data for wall-to-wall forest AGB estimation are exploiting an L-band polarimetric SAR. However, the saturation issues were reported for AGB estimation using L-band backscatter coefficients. Saturation varies depending on forest structure. Polarimetric information has the capability to identify different aspects of forest structure and therefore shows great potential for reducing saturation issues and improving estimation accuracy. In this study, 121 polarimetric decomposition observations, 10 polarimetric backscatter coefficients and their derived observations, and six texture features were extracted and applied for forest AGB estimation in a tropical forest and a boreal forest. A parametric feature optimization inversion model (Multiple linear stepwise regression, MSLR) and a nonparametric feature optimization inversion model (fast iterative procedure integrated into a K-nearest neighbor nonparameter algorithm, KNNFIFS) were used for polarimetric features optimization and forest AGB inversion. The results demonstrated the great potential of L-band polarimetric features for forest AGB estimation. KNNFIFS performed better both in tropical (R^2 = 0.80, RMSE = 22.55 Mg/ha, rRMSE = 14.59%, MA%E = 12.21%) and boreal (R^2 = 0.74, RMSE = 19.82 Mg/ha, rRMSE = 20.86%, MA%E = 20.19%) forests. Non-model-based polarimetric features performed better compared to features extracted by backscatter coefficients, model-based decompositions, and texture. Polarimetric observations also revealed site-dependent performances.

Keywords: forest AGB; polarimetric SAR observations; L-band; parametric and nonparametric feature optimization inversion methods

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1. Introduction

Climate change is an obvious impact of the continuous development of human beings on Earth. Deforestation and forest degradation contributed to the continuous increase in global carbon dioxide (CO_2) and accelerated climate warming [1,2]. How to control and balance the carbon cycle has become a new central issue in the global response to climate change. Forests play a crucial part in regulating global climate change through mechanisms including carbon absorption, carbon emission, and the control of the water and energy cycles [3,4]. The main carbon pools are typically affected by the change in the living forest aboveground biomass (AGB). The current carbon stock in the world's forests is estimated at 861 ± 66 Pg C, where 471 ± 93 Pg C (55%) is stored in tropical forests and 272 ± 23 Pg C (32%) in boreal regions. The contribution of tropical and boreal forests to the carbon budget was 1.64 Pg C/year and 0.5 Pg C/year between 1990 and 2007, respectively [5–8]. Understanding the dynamics of tropical and boreal forests AGB changes is essential for comprehending the impact of forest management on climate change [1].