Harnessing Earth Observation Data and Machine Learning for National Aboveground Biomass Assessment in Australia

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Abstract

Aboveground biomass (AGB) serves as a critical factor in the evaluation of carbon stocks, forest productivity, and the increased risk to bushfires in response to changing climate and land use patterns. For a comprehensive understanding of how bushfires and environmental degradation contribute to climate change, obtaining precise AGB estimates is imperative. While ground-level measurements offer the utmost accuracy in AGB data collection, they are often labor-intensive and time-consuming, which limits their practicality on larger scales. An alternative methodology involves merging ground-based data with satellite observations, providing a cost-effective avenue for estimating AGB across continental or global scales. The utilization of remote sensing data offers a reliable and extensive means for AGB estimation and continuous monitoring, facilitating a deeper exploration of these interconnected dynamics. In this paper, we introduce a study focused on utilizing open-access Earth observation products, including Sentinels missions (e.g., optical and Synthetic Aperture Radar (SAR) data) and the Global Ecosystem Dynamics Investigation (GEDI) to predict AGB at the national scale, specifically in the context of Australia. GEDI, NASA's full-waveform lidar sensor, has been instrumental in furnishing AGB estimates commencing from April 18, 2019, onwards. In the context of this study, the AGB estimates derived from GEDI's data are employed to compile training samples for the proposed machine learning (ML) method and to calibrate the AGB model based on Sentinels data. We employ the ML technique as a predictive model to extrapolate the AGB estimates derived from GEDI data across the entire area, utilizing multispectral Sentinel-2 data and SAR polarizations. Our results underscore the significance of incorporating multi-temporal optical and SAR data for precise AGB predictions. The AGB maps will prove invaluable for aiding firefighters in making informed decisions regarding prescribed burns and assessing the spread of bushfires when they occur. In essence, the integration of multispectral and temporal Sentinel-2 data, combined with SAR data trained on GEDI data, equips decision-makers with the essential resources to monitor biomass changes over time on continental or global scales.

Keywords: Aboveground biomass; GEDI; remote sensing; machine learning; LiDAR; Sentinel-2; SAR