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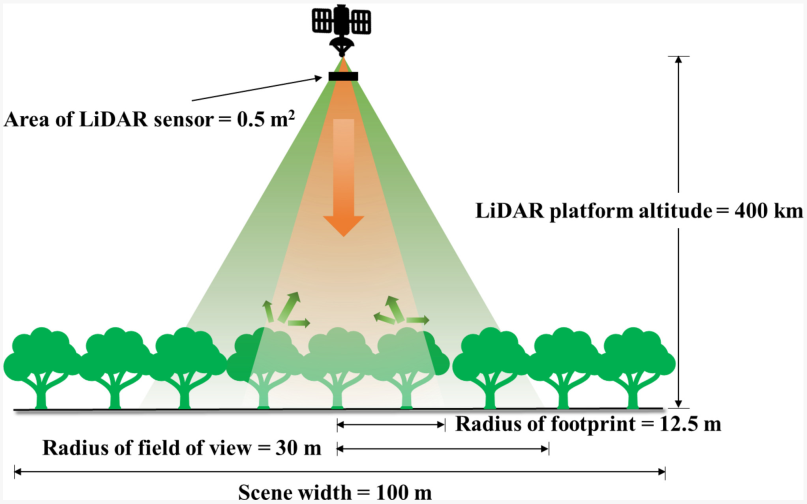
Sharper forest insights from spaceborne LiDAR



Scene and LiDAR configuration diagrams.

GA, UNITED STATES, April 2, 2026 /EINPresswire.com/ -- A new study shows that not all simplifications in spaceborne Light Detection and Ranging (LiDAR) modeling are equally reliable. By testing realistic forest canopies, researchers found that some assumptions, such as ignoring woody parts or using one representative leaf spectrum, have only minor effects on simulated waveforms. In contrast, assuming a uniform foliage area volume density can cause much larger errors, especially in clumped canopies. The work offers a clearer route to more accurate forest structure retrieval from satellite LiDAR data.

Spaceborne Light Detection and Ranging (LiDAR) has become a powerful tool for observing forest height, biomass, carbon stocks, and vertical canopy structure. Yet turning waveform signals into detailed structural information remains difficult because canopy elements are complex in shape, density, and spatial arrangement. Many analytical models therefore rely on simplified assumptions about leaves, branches, and canopy density. The problem is that these assumptions are not always tested against realistic forest scenes, making it hard to know which ones are safe and which ones distort the signal. Based on these challenges, deeper research is needed into how canopy structure influences LiDAR waveforms.

Researchers from Beijing Normal University, Université de Toulouse, the University of Hong Kong, and Hong Kong Polytechnic University published this study in the Journal of Remote Sensing on February 19, 2026. The team examined how structural assumptions in LiDAR waveform models affect the interpretation of forest canopies, aiming to improve the accuracy of satellite-based forest observation. Their work addresses a practical challenge in remote sensing: how to simplify forest structure enough for efficient modeling without losing the key features that control the LiDAR return signal.

Using the DART 3D radiative transfer model and eight realistic RAMI forest scenes, the study found that several common approximations are more robust than expected. Removing woody components and using a single representative leaf spectrum produced only very small waveform errors in nadir observations at 1,064 nm, with RMSE values at or below 7.0×10^{-6} mJ under the tested conditions. By contrast, assuming constant foliage area volume density, or FAVD, caused much stronger deviations, with RMSE values ranging from 7.4×10^{-6} to 9.0×10^{-5} mJ for voxel sizes from 0.1 to 1.0 m. The results also showed that vertical crown profiles and between-crown gaps play a major role in shaping the LiDAR signal.

The researchers simulated waveforms for eight structurally realistic forest scenes from the Radiative Transfer Model Intercomparison program. They tested the effects of excluding branches, replacing multiple leaf spectra with one spectrum, and converting realistic canopies into voxelized scenes of different sizes. When actual FAVD distributions were preserved, voxelization had little impact for voxel sizes up to 1 m, with RMSE staying at or below 1.8×10^{-5} mJ. But when FAVD was homogenized, errors increased because dense inner foliage was effectively redistributed toward canopy edges, reducing gap probability and weakening the ground return. The study further showed that broad canopy height variation can create multiple waveform peaks, while more uniform canopies produce smoother, simpler returns. These comparisons helped identify which canopy features most strongly control waveform shape and energy distribution.

Adapted press-style comment based on the paper's conclusions: “Our results suggest that future LiDAR analytical models should pay much closer attention to how foliage is distributed in space, rather than relying on overly uniform canopy descriptions. Better representation of crown profiles and canopy gaps could significantly improve the retrieval of forest structural information from spaceborne observations.”

The team used the Discrete Anisotropic Radiative Transfer model, or DART, to simulate full-waveform LiDAR signals. They reconstructed eight RAMI benchmark forest scenes and tested both facet-based realistic canopies and voxel-based canopy representations. Simulations used a 1,064-nm wavelength, a 0.1-mJ pulse energy, a 12.5-m footprint radius, and 500,000 photons per pulse. The researchers then compared waveform agreement using RMSE and coefficient of determination values under different structural assumptions.

This work could improve how satellites retrieve canopy height profiles, foliage structure, and biomass-related traits from LiDAR waveforms. It also provides guidance for designing faster analytical models that remain physically reliable. In the longer term, the findings may support more accurate global forest monitoring, carbon accounting, and ecosystem assessment by helping future remote-sensing systems better distinguish which forest details truly matter in waveform interpretation.

References
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