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| **Sensitivity of voxel size, leaf angle distribution and clumping factor in Leaf Area Density estimation in different forest types** |
| **Introduction/Aim**: Terrestrial Forest ecosystems are integral to the Earth's biosphere, significantly influencing global carbon flux through photosynthesis, transpiration, and carbon sequestration. Leaf Area Index (LAI) is a one-sided green leaf area per unit ground surface area that affects the microclimate and energy exchange. However, 2D LAI map representation cannot provide the detailed 3D spatial distribution of the leaves in a vertical profile.  The location and amount of leaf area is described as Leaf Area Density (LAD), the total leaf area per unit volume, which is considered a critical parameter in radiative transfer models.  LAD estimation using direct manual methods is a time consuming and labour-intensive endeavour. An effective non-destructive alternative is Terrestrial Laser Scanning (TLS) to obtain detailed three-dimensional (3D) structural properties of forests. TLS also enables the assessment of LAD at the plot scale by measuring pulse trajectories through voxel space (a 3D spatial unit).  However, the extent to which the voxel size, leaf angle distribution and foliage clumping influences the estimation of LAD in different forest types remains unclear. This issue is especially hard to solve in the real world without detailed reference data. To address this, 3D simulations of real and virtual canopies coupled with ray tracing radiative transfer models can be used to create a virtual reference to test LAD retrieval algorithms.  **Methods:** In this study, simulated LiDAR data using a 3D radiative transfer model (the Discrete Anisotropic Radiative Transfer (DART)) is used to analyse the sensitivity of LAD estimation arising from voxel size, leaf angle distribution, and the clumping factor. We use a novel LiDAR processing package, RayCloudTools ‘RCT’ combined with simulated LIDAR from a high-end commercial LiDAR system across three different forest types of Australia. The output from different sensitivity analyses is validated using this simulation approach.  **Results:** In previous studies, the RCT voxel method applied in vineyard leaf density estimation using a 10 cm voxel size and spherical leaf distribution has been shown to perform well. Preliminary results indicate the important trade-offs involved with voxel size and sampling density. Recommendations will be presented for how best to account for these trade-offs in a range of structural environments, including the importance of algorithm assumptions that are seldom tested (i.e. vegetation clumping within voxels).    **Conclusion:** This method takes advantage of ray depth penetration function of RCT and radiative transfer simulation to understand the suitable choice of voxel size, leaf angle distribution and clumping factor in three different Australian vegetation types. Sampling and voxel size recommendations will impact future data collection using this fast-growing indirect method of assessing 3D vegetation structure. Such methods can be used to benchmark remote retrievals from air- or space-borne platforms, like the GEDI spaceborne LiDAR mission. |