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| **A moderate resolution 3D forest structure map of New Zealand** |
| **Introduction/Aim:**New Zealand's unique flora and challenging landscapes have long made mapping the vertical structure of its woody vegetation particularly difficult. The complexity of the nation's forest ecosystems, dense foliage, and steep, varied terrain necessitate advanced methods for accurate vegetation structure characterisation. Addressing these challenges, a novel 10-m spatial resolution map that captures the height and cover of New Zealand's forest and woodland structure has been developed by integrating Sentinel-2, Sentinel-1, and Global Ecosystem Dynamics Investigation (GEDI) data sets.**Methods:**The mapping methodology leveraged Sentinel-2 optical imagery processed through time series modelling to construct a barest earth mosaic, critical for discerning forest structure across dense canopies and rugged terrains. Sentinel-1 SAR imagery, processed using a Radiometric Terrain Correction (RTC) model, mitigated topographic distortions prevalent in New Zealand's landscape, improving the accuracy of the vegetation backscatter interpretation. The higher spatial resolution of Sentinel-1 and -2, compared to previous datasets like Landsat ETM+ and ALOS PALSAR, allowed for a more detailed detection and characterisation of the variability in the structural types across the country. These data were combined using a singular value decomposition approach and then segmented into approximately 1 ha areas with similar structural typologies. A nationwide clustering approach was applied to recover segments with similar cover and backscatter areas. Finally, GEDI waveforms were aggregated within these clusters to provide fine-scale three-dimensional vegetation structure, adding vertical foliage profiles and structural metrics to the clustered segments, such as the 95th percentile height, mean height, and height to maximum vegetation density. **Results:**These classifications were applied nationwide, leveraging the class uniformity to extrapolate GEDI-derived metrics across different landscapes. Satellite-derived structural estimates were validated against field data from airborne LiDAR across various forest types and demonstrated high congruence. Variability within GEDI profiles were consistent across classes, with differences typically attributed to natural or anthropogenic changes. The result was a comprehensive national map of vegetation height, further enriched with coverage estimates to refine New Zealand's structural classifications.**Conclusion:**Integrating these diverse datasets—optical, SAR, and lidar—proved critical for segmenting and classifying land cover, extracting biophysical properties, and making significant strides in the comprehensive mapping of New Zealand's forests. Such enhanced forest structure mapping has broad applications, including effectively quantifying carbon stocks, biodiversity conservation, forest health assessments, change monitoring, and informing environmental policy decisions. This study lays the groundwork for incorporating next-generation satellite and lidar technologies to advance large-area forest structural assessments in New Zealand. |