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| **Towards satellite product validation using multi-scale lidar** |
| **Introduction:**  Forests around the globe are experiencing significant changes in their structure and species composition due to human land use and global climate change. Essential Biodiversity and Climate Variables (EBVs/ECVs) provide a quantitative basis for monitoring these changes through space and time, and to evaluate the effectiveness of conservation and management strategies. However, the tools currently available for large-scale ecosystem monitoring, particularly from space, are not specifically designed for detailed vegetation observation, and they lack the spatial and temporal resolution needed to capture the full three-dimensional structure of vegetation and vegetation change at local scales.  The challenges in monitoring forest dynamics related to (up)scaling are twofold: first, the impact of dynamics on forest structure at local levels and, second, the detection and monitoring of dynamics or disturbances globally using satellite data. Traditional ground-based plots, while offering precise 3D structural data through terrestrial laser scanning (TLS), are limited by their size and the frequency of data collection. This makes them less ideal for satellite calibration and validation (cal/val) in the context of forest dynamics monitoring.  **Aim/Methods:**  To bridge this gap, multi-scale laser scanning aims to enhance reference data for validating spaceborne measurements. Multi-scale laser scanning can be across spatial or temporal scales, or both.  **Results:**  This presentation highlights the benefits of multi-scale laser scanning through findings from two distinct projects: one across spatial scales and one across temporal scales. The first project involves a network of permanent tropical forest plots in Australia, analysed using both terrestrial and UAV laser scanning (UAV-LS). This study spans a range of rainfall and altitude conditions and compares data collected in 2018 and 2024 to assess biomass dynamics. Our results affirm the effectiveness of TLS in accurately capturing key structural tree metrics at the plot scale and the use of UAV-LS in quickly and accurately measuring canopy tree structures across larger landscapes. The fusion (i.e. combined datasets) of TLS and UAV-LS data is not crucial for individual tree measurements but primarily serves as a means to upscale stand-alone UAV-LS structural measurements at the landscape-scale.  The second project introduces an automated permanent laser scanning network across six supersites in Germany and Belgium. This setup, utilising high-temporal-resolution (daily) scanning, moves beyond the limitations of conventional TLS methods, allowing for continuous monitoring of ecosystem structure and its correlation with ecosystem functioning, specifically microclimate dynamics or phenology. Equipped with LEAF automated laser scanners and microclimate loggers, these supersites provide valuable insights and practical considerations into daily and seasonal variations in plant area volume density and the effect on local ecosystem processes.  **Conclusion:**  Multi-scale laser scanning is important in providing objective, accurate, and precise in situ reference measurements in support of conservation and management strategies across spatial and temporal scales. Initiatives like GEO-TREES stand to benefit significantly from advancements in multi-scale laser scanning, offering high-accuracy reference data for satellite-based biomass mapping. Moreover, the development of automated monitoring networks (e.g. StrucNet) is essential for generating the calibration data needed by satellite missions to effectively monitor vegetation structural dynamics over extensive areas. |