CONSTRUCTING A LARGE AREA VIRTUAL VALIDATION FOREST STAND FROM TERRESTRIAL LiDAR

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ABSTRACT

Spaceborne remote sensing plays an important role in collecting long-term consistent global data to underpin climate change research efficiently. These observations are used to derive biophysical essential climate variables (ECVs) that enable large-scale evaluation of the response of vegetation to changes in climate. ECVs such as leaf/plant area index (LAI/PAI), fraction of absorbed photosynthetically active radiation (fAPAR) and albedo are good indicators of small fluctuations in terrestrial vegetation over time. The validation of spaceborne ECV products is generally based on comparison either with in situ estimates or with reference products from different earth observation missions. However, most of these methods estimate biophysical quantities indirectly using a variety of assumptions and hypotheses. Therefore, direct comparison (true ‘validation’) and end-to-end traceability of in situ measurements and satellite-derived ECV’s observations are difficult.

We suggest a framework for understanding, calibrating and validating in situ and satellite fAPAR and PAI estimates by generating a set of reference measurements using forest structural models to drive radiative transfer (RT) models. If these models can be used to simulate ground-based and EO data, we can control all aspects of sensor and environment properties, which would not be possible using measured data. Subsequently, biases resulting from differing algorithm assumptions can be quantified. RT models require canopy structure to be quantified. The introduction of terrestrial laser scanning (TLS), also referred to as terrestrial LiDAR, has enabled the possibility of generating tree models based on 3D scans. We present a processing chain that uses terrestrial LiDAR data and tree reconstruction to represent the explicit 3D forest structure used in radiative transfer models.

Our study area is a 6 ha deciduous forest at Wytham, Oxford, UK. TLS and PAI data were collected representing full leaf-on conditions during the summer of 2015 and leaf-off during winter 2015/16. TLS data were collected with a RIEGL VZ-400 terrestrial laser scanner at 176 scan locations within a 20 x 20 m regular grid pattern across the study area. PAI data were collected using several techniques and instruments including digital hemispherical photography (DHP), Li-Cor LAI-2000 and LAI-2200. We employed the VALERI sampling design for these optical PAI measurements (1800 measurements in total). The librat 3D Monte Carlo ray tracing (MCRT) RT model is employed to simulate DHPs, LAI-2000 and LAI-2200 measurements. This model requires a 3D explicit description of the forest structure, and spectral information about the canopy constituents used to represent the forest structure.

We use TLS data to reconstruct tree models using the quantitative structure model (QSM) approach in [1-2] to model the stem and branching structure. Addition of the leaves is based
on the derived light availability extracted from the point cloud and comparison of the leaf on and leaf-off scan data. Field measurements from the FieldSpec (ASD Inc.) were collected to provide the spectral characteristics of the leaves, bark and understory. The various field instruments used here have been characterised radiometrically and geometrically, enabling calibration information to feed directly into the simulation framework process. As a result, this work provides for the first time an explicit framework for quantifying end-to-end traceability of various in situ fAPAR and PAI estimates RT modelling, stand reconstruction from TLS data and comparison of field estimates with simulations. To our knowledge, this study is the first reconstruction of a large (> 1 ha) study site directly from TLS data that can be used in a RT model to calibrate and validate ground-based, airborne and spaceborne sensors. Furthermore, the intensive sampling design that was deployed in the field will allow us to address issues of spatial variance and quantify the effect of different sampling strategies on the inferred ECVs.

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REFERENCES