Geophysical Research Abstracts
Vol. 19, EGU2017-6501, 2017
EGU General Assembly 2017

Directional radiative transfer by SCOPE, SLC and DART using laser scan derived structural forest parameters

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Accurate estimation of the radiative transfer (RT) over vegetation is the corner stone of agricultural and hydrological remote sensing applications. Present remote sensing sensors mostly use traditional optical, thermal and microwave observations. However with these traditional observations characterization of the light efficiency and photosynthetic rate can only be accomplished indirectly. A promising new method of observing these processes is by using the fluorescent emitted radiation. This approach was recently highlighted due to the selection of the FLEX sensor as a future Earth Explorer by the European Space agency (ESA). Several modelling activities have been undertaken to better understand the technical feasibilities of this sensor.

Within these studies, the SCOPE model has been chosen as the baseline algorithm. This model combines a detailed RT description of the canopy, using a discrete version of the SAIL model, with a description of photosynthetic processes (by use of the Farquhar/Ball-Berry model). Consequently, this model is capable of simulating simultaneously the biophysical processes and jointly the fluorescent, optical and thermal RT. The SAIL model however is a 1D RT model and consequently provides higher uncertainties with increasing vegetation structures.
The main objective of this research is to investigate the limitations of the RT model component of the SCOPE model over complex canopies. In particular the aim of this research is to evaluate the validity for increasingly structural complex canopies', on the bidirectional reflectance distribution functions (BRDF) of these canopies. This was accomplished by evaluating the simulated outgoing radiation from SCOPE/SAIL against simulations of the DART 3D RT model. In total nine different scenarios were simulated with the DART RTM with increasing structural complexity, ranging from the simple 'Plot' scenario to the highly complex 'Multiple Crown' scenario. The canopy parameters are retrieved from a terrestrial laser scan of the Speulderbos in the Netherlands.

The comparison between DART and SCOPE/SLC models showed a good match for the simple scenarios. Calculated rMSDs showed lower than 7.5% errors for crown coverage values lower than 0.87, with the Near-Hotspot viewing angles found to be the largest contributor to this deviation. For more complex scenarios (using Multiple Crowns), the comparison between SCOPE and DART showed mixed results. Good results were obtained for crown coverage values of 0.93, with rMSD (6.77% and 5.96%), lower than the defined threshold value, except near hotspot. For scenarios with crown coverages lower than 0.93 the rMSD were too large to validate the use of SCOPE model. When considering the Soil Leaf Canopy (SLC) model, an improved version of SAIL that considers the canopy clumping, better results were obtained for these complex scenarios, with good agreement for medium crown coverage values (0.93 and 0.87) with rMSD (6.33% and 5.99; 6.66% and 7.12%). This indicates that the radiative transfer model within SCOPE might be upgraded in the future.