Research Project: Retrieval of plant biophysical and biochemical variables from remote sensing data using a hybrid machine learning method

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Abstract

This will be the abstract at the end [TO BE UPDATED]

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List of Abbreviations

3D . . . . Three-dimensional

INFORM . . . Invertable Forest Reflectance Model

RTM . . . . . . Radiative Transfer Model

SAIL . . . . . . Scattering by Arbitrary Inclined Leaves

PROSAIL . . The combination of PROSPECT and SAIL models

FLIM . . . . . Forest Light Interaction Model

LAI . . . . . . Leaf Area Index

MLRA . . . . Machine Learning Regression Algorithms

ML . . . . Machine Learning

DT . . . . Decision Trees

ANN . . . . . . Artificial Neural Networks

KBMLRM . . Kernel-Based Machine Learning Regression Methods

RF . . . . Random Forest

RFR . . . . . . Random Forest Regression

LUT . . . . . . Look-Up-Table

NN . . . . Neural Networks

SVR . . . . . . Support Vector Regression

SVM . . . . . . Support Vector Machines

GPR . . . . . . Gaussian Process Regression

GP . . . . Gaussian Process

VI . . . . Vegetation Index

DR . . . . Dimensionality Reduction

WT . . . . . . Wavelet Tranform

PCA . . . . . . Principal Component Analysis

AL . . . . Active Learning

1 Methods

This section explains the methods used in this research.

1.1 Local sensitivity analysis

Local sensitivity analysis was performed to assess the effect of each of the main 6 plant biochemical and biophysical variables on the PRISMA image bands. In the local sensitivity analysis simulation is performed by keeping all the variables constant at their determined fixed or default values except the parameter of interest. This way the effect of a specific parameter on the simulated spectra can be assessed. In this research the plant parameters C_{ab}, C_w, C_m, LAI_s, CD and SD were varied each 15 times (Table (1.1)), while keeping the rest of the variables at their default values (Table (1.2)). The default and varied values were chosen based on the literature (e.g. Darvishzadeh et al. (2019); Laurent et al. (2011); Schlerf and Atzberger (2012)) where similar RTM method used to simulate reflectance for Spruce trees.

Table (1.1) show the 6 parameters that were varied, their units, minimum and maximum values. Each parameter was varied 15 times, meaning 15 different spectra were simulated for each variable.

Table 1.1: INFORM Parameters varied in local sensitivity analysis (each parameter were varied 15 times)

Parameter	Abbrev.	Unit	Min	Max
Chlorophyll content	C_{ab}	$\frac{\mu g}{cm^2}$	20	60
Equivalent water thickness	C_w	$\frac{g}{cm^2}$	0.0035	0.035
Leaf dry matter content	C_m	$\frac{g}{cm^2}$	0.008	0.03
Leaf area index (single)	LAI_s	$\frac{m^2}{m^2}$	0	7
Stem density	SD	ha^{-1}	200	5000
Crown diameter	CD	m	1.5	8.5

Table (1.2) show the determined default values for each INFORM parameter that were kept during the sensitivity simulation while one of the parameter was varied (Table (1.1)).

Table 1.2: INFORM Parameters that were kept constant while one parameter was varied at a time

Parameter	Abbr	Unit	Value
Leaf structure parameter	N	$-$	3
Chlorophyll content	C_{ab}	$\frac{\mu g}{cm^2}$	40
Leaf cartenoid content	C_{ar}	$\frac{\mu g}{cm^2}$	8
Brown Pigment Content	C_{brown}	$-$	0.001
Equivalent water thickness	C_w	$\frac{g}{cm^2}$	0.0117
Leaf dry matter content	C_m	$\frac{g}{cm^2}$	0.03
Average leaf inclination angle	$ALIA$	$^\circ$	65
Leaf area index (single)	LAI_s	$\frac{m^2}{m^2}$	6
Leaf area index (understorey)	LAI_u	$\frac{m^2}{m^2}$	0.5
Hot spot parameter	Hot	$\frac{m}{m}$	0.02
Solar zenith angle	tts	$^\circ$	45.43
Observer zenith angle	tto	$^\circ$	0
Sun-sensor azimuth angle	psi	$^\circ$	181.41
Soil brightness	α_{soil}	$-$	0.5
Stem density	SD	ha^{-1}	700
Crown diameter	CD	m	5
Mean Height	H	m	20
Fraction of diffuse incoming	$skyl$	$-$	0.1
Soil reflectance spectrum	B_g	$-$	default

Solar zenith angle and *Sun-sensor azimuth angle* were calculated based on the PRISMA image acquisition parameters (date, lat/long etc.) using the website `https://www.esrl.noaa.gov/gmd/grad/solcalc/azel.html`.

RTM models PROSPECT5, 4SAIL and FLIM were coupled (INFORM) in order to simulate canopy reflectance. Simulations were carried out using the *ccrtm* package (Visser, 2021) in *R* (R Core Team, 2021). The default soil spectra provided by the the *ccrtm* package (Visser, 2021) was used for the simulations.

References

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