pyPro4Sail Documentation

Release 1.0.0

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Contents

Prospect5 and 4SAIL Radiative Transfer Models for simulating the transmission of radiation in leaves and canopies.

CHAPTER 1

Summary

This project contains *Python* code for *Prospect* and *4SAIL* Radiative Transfer Models (**RTM**) for simulating the transmission of optical and thermal electromagnetic radiation through leaves and vegetated canopies.

CHAPTER 2

Contents

2.1 README

Prospect5 and 4SAIL Radiative Transfer Models for simulating the transmission of radiation in leaves and canopies.

2.1.1 Synopsis

This project contains *Python* code for *Prospect* and *4SAIL* Radiative Transfer Models (**RTM**) for simulating the transmission of optical and thermal electromagnetic radiation through leaves and vegetated canopies.

The project consists of:

1. lower-level modules with the basic functions needed in *Prospec5* and *4SAIL* RTMs.
2. higher-level scripts for easily running ProSAIL in both forward and inverse mode.

2.1.2 Installation

Download the project to your local system, enter the download directory and then type.

```
python setup.py install
```

if you want to install pyTSEB and its low-level modules in your Python distribution.

The following Python library ir required for running Prospect and 4SAIL:

- Numpy

In addition, the inversion of both RTMS requires.

- Scipy
- cma [Optional]

2.1.3 Code Example

High-level example

You can automatically run the coupled leaf+canopyt Prospect5+4SAIL RTM with *pyPro4Sail.py* module.

```
[N, chloro, caroten, brown, EWT, LMA, LAI, hot_spot, solar_zenith, solar_azimuth,␣
↪view_zenith, view_azimuth, LIDF]=[1.5,40,8,0.0,0,01,0,009,3,0.01,30,180,10,180,(-
↪0.35,-0.15)]
import pyPro4SAIL
wl,rho=pyPro4SAIL.run(N, chloro, caroten, brown, EWT, LMA, LAI, hot_spot, solar_
↪zenith, solar_azimuth, view_zenith, view_azimuth, LIDF, skyl=0.2,␣
↪soilType=pyPro4SAIL.DEFAULT_SOIL)
```

Also it is possible to simulate the surface land-leaving thermal radiance with the function `run_TIR`.

Low-level example

Prospect5 RTM

You can run *Prospect* by importing the module Prospect5.py and then either calling the function `Prospect5` for simulating the full optical spectrum (400-2500nm), or the function `Prospect5_wl` for simulating the leaf reflectance and transmittance for a given wavelength.

```
# Running Prospect5
import Prospect5
# Simulate leaf full optical spectrum (400-2500nm)
wl, rho_leaf, tau_leaf = Prospect5.Prospect5(Nleaf, Cab, Car, Cbrown, Cw, Cm)
```

You can type `help(Prospect5.Prospect5)` to understand better the inputs needed and the outputs returned

4SAIL RTM

You can run *4SAIL* by importing the module FourSAIL.py and then either calling the function `FourSAIL` for simulating the reflectance and transmittance factor of a given canopy given a list of leaf reflectances and trasmittances, or you can call the function `FourSAIL_wl` for simulating the leaf reflectance and transmittance factor of a given canopy at for a single wavelenght.

```
# Running the coupled Prospect and 4SAIL
import Prospect5, FourSAIL
# Simulate leaf full optical spectrum (400-2500nm)
wl, rho_leaf, tau_leaf = Prospect5.Prospect5(Nleaf, Cab, Car, Cbrown, Cw, Cm)
# Estimate the Leaf Inclination Distribution Function of a canopy
lidf = CalcLIDF_Campbell(alpha)
# Simulate leaf reflectance and transmittance factors of a canopy
tss,too,tsstoo,rdd,tdd,rsd,tsd,rdo,tdo,rso,rsos,rsod,rddt,rsdt,rdot,rsodt,rsost,
↪rsot,gammasdf,gammasdb,gammasowl = FourSAIL.FourSAIL(lai,hotspot,lidf,SZA,VZA,
↪PSI,rho_leaf,tau_leaf,rho_soil)
# Simulate the canopy reflectance factor for a given difuse/total radiation␣
↪condition (skyl)
rho_canopy = rdot*skyl+rsot*(1-skyl)
```

You can type `help(FourSAIL.FourSAIL)` to understand better the inputs needed and the outputs returned

2.1.4 Basic Contents

High-level modules

- *.src/pyPro4SAIL.py*

  Runs the coupled Prospect5+4SAIL to estimate the canopy directional reflectance factor and 4SAIL to estimate the land-leaving broadband thermal radiance.

Low-level modules

The low-level modules in this project are aimed at providing customisation and more flexibility in running TSEB. The following modules are included.

- *.src/Prospect5.py*

  core functions for running Prospect5 Leaf Radiative Transfer Model.

- *.src/FourSAIL.py*

  core functions for running 4SAIL Canopy Radiative Transfer Model.

- *.src/CostFunctionsPROSPECT4SAIL.py*

  merit functions used to invert Prospect and/or 4SAIL from a given spectrum

- *.src/cma.py*

  Covariance Matrix Adaptation Evolution Strategy optimization method for inverting Prospect5 and/or 4SAIL.

2.1.5 API Reference

http://pyPro4Sail.readthedocs.org/en/latest/index.html

2.1.6 Main Scientific References

- S. Jacquemoud, F. Baret, PROSPECT: A model of leaf optical properties spectra, Remote Sensing of Environment, Volume 34, Issue 2, November 1990, Pages 75-91, ISSN 0034-4257, http://dx.doi.org/10.1016/0034-4257(90)90100-Z.
- Jean-Baptiste Feret, Christophe François, Gregory P. Asner, Anatoly A. Gitelson, Roberta E. Martin, Luc P.R. Bidel, Susan L. Ustin, Guerric le Maire, Stéphane Jacquemoud, PROSPECT-4 and 5: Advances in the leaf optical properties model separating photosynthetic pigments, Remote Sensing of Environment, Volume 112, Issue 6, 16 June 2008, Pages 3030-3043, ISSN 0034-4257, http://dx.doi.org/10.1016/j.rse.2008.02.012.
- W. Verhoef, Light scattering by leaf layers with application to canopy reflectance modeling: The SAIL model, Remote Sensing of Environment, Volume 16, Issue 2, October 1984, Pages 125-141, ISSN 0034-4257, http://dx.doi.org/10.1016/0034-4257(84)90057-9.
- W. Verhoef, L. Jia, Q. Xiao and Z. Su, Unified Optical-Thermal Four-Stream Radiative Transfer Theory for Homogeneous Vegetation Canopies, IEEE Transactions on Geoscience and Remote Sensing, vol. 45, no. 6, pp. 1808-1822, June 2007. http://dx.doi.org/10.1109/TGRS.2007.895844.

2.1.7 Tests

to be included

2.1.8 Contributors

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- **Radoslaw Guzinski**
- **Robin Wilson** robin@rtwilson.com main developer of pyProSail https://github.com/robintw/PyProSAIL

2.1.9 License

2.2 pyPro4SAIL package

2.3 Prospect5 package

2.4 FourSAIL package

2.5 Prospect5Jacobian package

2.6 FourSAILJacobian package

2.7 CostFunctionsPROSPECT4SAIL package

CHAPTER 3

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