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# Unified Inversion of Land Surface Parameters by Exploiting Optical-Thermal Remote Sensing Observations

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## ➢ Background

- Current global products
  - Generally parameter-specific algorithms
  - Based on instantaneous physical models
  - Spatial, temporal and physical inconsistencies

- Optical to Thermal Infrared (TIR) remote sensing observations
  - Separated to use
  - Middle InfraRed (MIR) observations have received little attention

A unified algorithm is proposed for simultaneously retrieving a total of five types of land surface parameters, including Leaf Area Index (LAI), Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), surface albedo, Land Surface Temperature (LST), and surface emissivity, by exploiting remote sensing observations from visible to TIR domain based on a unified Optical-Thermal physical Radiative Transfer (RT) model and a data assimilation framework.

## ➢ Methods

The basic procedure of the proposed method is briefly illustrated in Fig. 1. At first, LAI was estimated using a data assimilation method that combines MODIS visible to MIR observations and a phenology model, based on the unified RT model. The estimated LAI values were then input into the RT model to simulate surface emissivity and surface reflectance. Using data from the RT model simulation, the black-sky, while-sky and actual albedo were calculated. Besides, the background albedo and the transmittance of solar radiation down to the background, and the canopy albedo were also calculated to produce FAPAR values at the given wavelengths, which were then used to produce FAPAR over the range of 400-700 nm. At last, LST were estimated by exploiting MODIS TIR data and the simulated emissivity using the split-window algorithm.

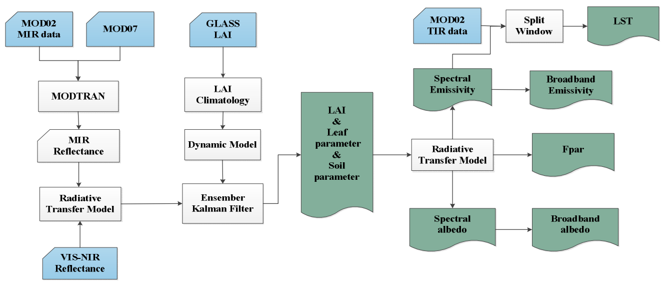


Fig. 1. Flowchart of simultaneous estimation of LAI, FAPAR, surface emissivity, surface albedo and LST by integration of optical to TIR remote sensing.

## ➢ Data Sources and Pre-procession

MODIS surface reflectance product (MOD09)
MODIS L1B radiance product (MOD02)
MODIS L1B geolocation product(MOD03)
MODIS Atmospheric Profiles product (MOD07)

MODIS LAI/FAPAR (MOD15A2)
MODIS albedo (MCD43A)
MODIS LST and Emissivity (MOD11A2)

GLASS LAI
GLASS BBE
Globalbedo albedo.

- Atmospheric correction of the MIR data—MODTRAN 5

$$I_i^* = \tau_i I_{G,i} + I_i^{atm\uparrow}$$

$$I_{G,\mathrm{i}} = B\left(T_{G,i}\right) = \varepsilon_i\left(\theta_v\right) B\left(T_s\right) + \left(1-\varepsilon_i\left(\theta_v\right)\right) I_i^{atm\downarrow} + \rho_i\left(\theta_v,\theta_s,\varphi\right) E_{sun,i}$$

## ➢ Radiative Transfer Model

Radiative transfer models are useful in developing inversion procedures to accurately retrieve vegetation properties from remote sensing data. In this study, a unified optical-thermal soil-canopy-leaf radiative transfer model was constructed at first to model the top-of-canopy directional reflectance /radiance.

Tabel 1. Construction of the unified optical-thermal soil-canopy-leaf radiative transfer model

| | VIS-SWIR | MIR | TIR |
|---|---|---|---|
| Canopy | PROSAIL | 4SAIL | 4SAIL |
| Leaf | PROSPECT | PROSPECT-VISIR | Leaf Spectrum Library |
| Soil | PRICE soil BRDF model | Soil Spectrum Library | Soil Spectrum Library |

Tabel 2. Input parameters of the unified optical-thermal soil-canopy-leaf radiative transfer model

| Name | Symbol | Units | Initial estimate | Lower boundary | Upper boundary |
|---|---|---|---|---|---|
| Leaf area index | *LAI | - | | 0 | 7 |
| Chlorophyll a+b content | *Cab | μg $cm^{-2}$ | 40 | 0 | 100 |
| Equivalent water thickness | *$C_w$ | $cm^{-1}$ | 0.02 | 0.0004 | 0.04 |
| Dry matter content | *$C_m$ | g $cm^{-2}$ | 0.005 | 0.0019 | 0.0165 |
| Leaf structure parameter | N | - | 1.5 | - | - |
| Leaf inclination distribution function | LIDF a | - | -0.35 | - | - |
| | LIDF b | | -0.15 | | |
| Hot spot parameter | $S_L$ | - | 0.05 | - | - |
| Weight of the first Price function | *$S_1$ | - | 0.2 | 0.05 | 0.4 |
| Weight of the second Price function | *$S_2$ | | 0.07 | -0.05 | 0.05 |

## ➢ Results

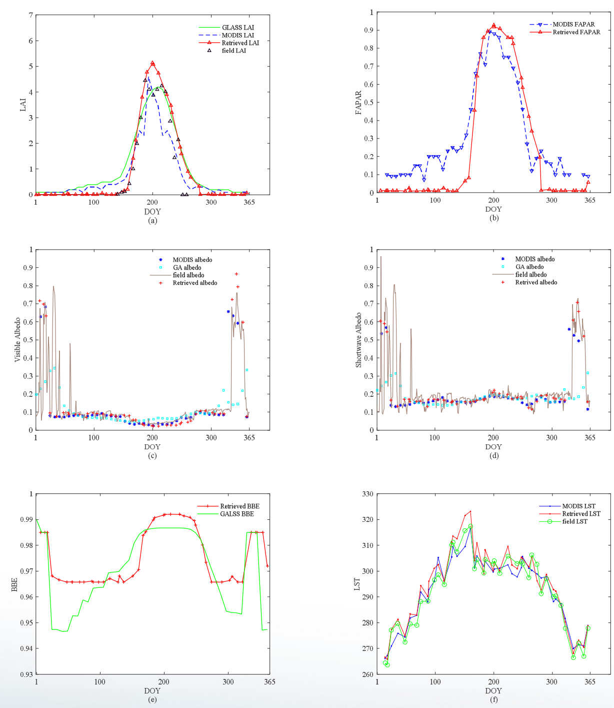


Fig.2. Time series for LAI, FAPAR, visible and shortwave albedo, BBE and LST at the Bondville site in 2005

Comparisons between the existing products and field meausurements have demonstrated that this unified inversion algorithm can retrieve temporally complete and physical consistent land surface parameters with high accuracy.

➢ Acknowledgements

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