

EMR response: vegetation

Vegetation properties from RS

- Critical inputs to land surface process models, driving biochemical models, & other biospheric functions
 - Albedo
 - Leaf area index (LAI)
 - Fractional photosynthetically active radiation (FPAR) absorbed by canopy
 - Surface roughness
 - Phenology

Vegetation models

- Physically-based canopy reflectance models that link canopy properties with sensor-measured radiance
 - Radiative transfer models
 - Geometric optical models
 - Computer simulation models

Canopy radiative transfer formulation

- Canopy configuration
 - 1-D turbid medium (atmosphere & water) with canopy elements randomly distributed
 - Canopy field with leaves – fig. 3.1
- Canopy architecture
 - Leaf area index (LAI)
 - Leaf angle distribution (LAD)
 - Leaf dimension
- Suitable for dense vegetation canopies

One-dimensional radiative transfer equation

- Early modeling work
 - Suits (1972) model
 - Vertical & horizontal leaves
 - Canopy structure & solar/viewing geometry
 - Verhoef (1984) model – SAIL (light scattering by arbitrarily inclined leaves) canopy model
 - Gastellu-Etchegorry et al. (1996) improved SAIL by considering anisotropic behavior of soil background

One-dimensional radiative transfer equation

- Use a flat homogeneous canopy
- Diffuse scattering of the leaves
 - Bi-Lambertian scattering model
- Interactions of photons with leaves
 - Specular reflectance
 - Lambertian diffuse reflectance
 - Lambertian diffuse transmittance
 - Controlled by canopy configurations & its optical properties



Boundary conditions

- Need to specify upper (bottom of atmosphere) & lower boundary conditions
- Determine sky radiance distribution
 - Depends on reflectance from canopy
 - Iterative process



Hotspot effects

- Hotspot – a reflectance peak around a viewing direction that is exactly opposite the solar illumination direction
- Based on shadow hiding theory
 - Viewing direction coincides with the solar viewing direction – no shadows are seen & observed radiance reaches a local maximum



Hotspot effects

- Hotspots one of most information-rich subregions in a BRDF space
- Retrieve canopy structural parameters
 - Leaf size & shape
 - Tree crown size
 - Canopy height for low-LAI stands



Formulations for heterogeneous canopies

- Canopy heterogeneity – row crops or orchards with isolated tree crowns
- DART (discrete anisotropic radiative transfer) model
 - 3D Cartesian geometry



Leaf optical models

- Leaf reflectance – Fig. 3.8 – typical response characteristics of green vegetation
- Optical properties of scattering elements – leaves (microstructure & material property of leaves) – are needed in a canopy model
- Want to retrieve biochemistry from canopy reflectance observations
- Suitable for handling sparse vegetation canopies with regular shaped crowns



“Plate” models

- PROSPECT (Allen et al. 1969) model simulates leaf reflectance & transmittance – broadleaf canopies
 - Uses geometric optical principles
 - Index of refraction & absorption coefficient

Needleleaf models

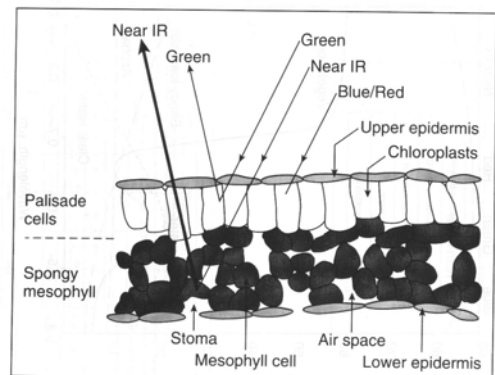
- LIBERTY (leaf incorporating biochemistry exhibiting reflectance & transmittance yields)
- Linear summation of individual absorption coefficients of major constituent leaf chemicals, according to their content per unit area of leaf

Ray tracing models

- Detailed description of individual cells & their unique arrangement inside tissues
- Optical constants of leaf materials defined

Stochastic models

- Stochastic leaf optical models based on Markov chain theory
- Probability of occurrence of leaf states – Fig. 3.12 – described by the elements of a vector – state vector



(Avery & Berlin 1992)

Turbid medium models

- Use Kubelka-Munk theory – consider leaf as a slab of diffusing & absorbing material

Solving radiative transfer eqs.

- Numerical & approximate solutions
- Several examples described in text



Geometric optical (GO) models

- Canopy consists of a series of regular geometric shapes placed on the ground
- Li & Strahler (1985) model



Computer simulation models

- Use for accurate computation of the radiation distribution over a complex canopy configuration
- Want to understand the radiation regime & validate some simplified models
- Retrieve biophysical parameters



Computer simulation models

- Typical methods:
 - Monte Carlo ray tracing (MCRT)
 - Forward & reverse ray tracing
 - Combination – bidirectional ray tracing
 - Radiosity (radiant existence) method
 - Based on light transport (or rendering) eq.
 - computer graphics applications, realistic scene rendering