Canopy Reflectance Model Inversion and the BRDF

M.J. Barnsley (2007)
Remote Sensing of the Land Surface

Effect of surface structure

Forward scatter  Nadir-view  Backscatter

Anisotropic reflectance

Direct and diffuse radiation
Bidirectional Reflectance Distribution Function (BRDF)

\[ \text{BRDF} = f(x, y, z; \Omega_i, \Omega_e; \lambda; P; t) \]

- \( x, y, z \): location of the point of reflection
- \( \Omega_i \): direction (zenith and azimuth) of incident radiation
- \( \Omega_e \): direction (zenith and azimuth) of the exitant radiation
- \( \lambda \): wavelength of radiation
- \( P \): polarization
- \( t \): time

**Canopy reflectance models: turbid medium**

- Find mathematical model to *describe* and *account* for BRDF, preferably one based on physics of shortwave radiation transport and specified in terms of measurable biophysical properties
- *Invert* directional reflectance data against model to estimate values of driving variables/properties

(Barnsley et al. 1997)

(Goel 1987)
Canopy reflectance models: geometrical optics

Canopy reflectance models: hybrid

Canopy reflectance models: computer simulation

Monte Carlo Ray-Tracing (MCRT) models
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Remote Sensing of the Land Surface
Surface structure
BRDF
Canopy reflectance models
Model inversion
References

FLIGHT: forward and inverse mode

Forward mode
Reverse mode

FLIGHT: conifer forest scene

FLIGHT: birch forest scene

BRDF modelling issues

- Physically-based models complex and highly non-linear, requiring use of numerical methods to solve model inversion problem (Goel 1989, Verstraete et al. 1996)
- Numerical inversion routines computationally-intensive and often highly sensitive to initial estimates of model parameters
- Model parameters are often coupled
- Implicitly assume homogeneous land cover type within each pixel, but typically deal with 250 m–1 km spatial resolution devices
- Available independent observations typically small in number and sub-optimally distributed throughout viewing/illumination hemisphere (Barnsley et al. 1994)
Kernel-Based BRDF Model

\[ \rho_\lambda(\theta_i, \phi_i; \theta_r, \phi_r) = f_{iso} + f_{geo}k_{geo} + f_{vol}k_{vol} \]

- Kernels, \( k \), defined in terms of Sun-target-sensor geometry — describe typical BRDF ‘shapes’ resulting from geometric protrusions or scattering within volume of the canopy (Strahler et al. 1999)

- Find values of kernel weights, \( f \), that give optimum fit to observed bidirectional reflectance measurements

- In principle, formulation of kernel weights specified in terms of measurable biophysical properties, such as Leaf Area Index (LAI), leaf reflectance (\( s \)), etc.
  - \( f_{iso} = \alpha C + (1 - \alpha)(\frac{s}{\pi} + \exp^{-LAI}\beta(p_0 - \frac{s}{\pi})) \)
  - \( f_{vol} = (1 - \alpha)\frac{4\pi}{3\pi}(1 - \exp^{-LAI}\beta) \)
  - \( f_{geo} = \alpha CL\pi r^2 \)
Temporal Upscaling Method

- Meteorological Data (BADC)
- Temperature, Irradiance
- Plant Growth Model (SUCROS)
- Canopy Reflectance Model (Kuusk)
- Leaf and Soil Optical Properties (Library values/PROSPECT)

Spatial Up-Scaling Method

- Landsat ETM+
- Land cover classification
- LAI (1 km)
- LAI (30 m)
Barton Bendish: NIR $f_{ISO}$

Thetford Forest: NIR $f_{ISO}$

References


