Updates to surface reflectance for trace gas retrievals

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Ozone absorption in the Visible

- Ozone has weak spectral features in the Chappuis band

- Since the atmosphere is optically thin in the visible, can get information near the surface

- But retrieval is more sensitive to errors in surface reflectance

- Spectral variation
- Dependence on land cover
- Changes with viewing geometry

Pictures by Don Deering
Reflectance Spectra by Surface Type

- Obtained lab spectra of possible ground cover
  - Includes vegetation, soils, rocks, manmade materials
- **Update:** added spectra from USGS database, have collaborators at SLU who are compiling a new albedo database
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- **Update**: added 4th EOF for use in trace gas retrievals.
Viewing Geometry from MODIS

Bidirectional Reflectance Distribution Functions: Causes

- Mirror BRDF: specular reflectance
- Volume scattering BRDF: leaf/vegetation reflectance
- Gap-driven BRDF (Forest): shadow-driven reflectance

MODIS Composite Surface Reflectance (True Color)

[Schaaf et al. 2002]
Seasonal Variation

We combine MODIS data at discrete bands with EOFs to create best estimate of surface reflectance spectra.
Reflectance as a function of solar position

MODIS BRDF factors allow us to reconstruct the geometric variation of reflectance – even at wavelengths not measured by MODIS!
Reflectance as a function of solar position

Reflectance at 600 nm

- Forested Scene, NY State
- VZA = 57°

Reflectance at 680 nm from aircraft (vegetated scene)

- Boston, MA
- VZA = 23°

Ratio of Reflectance 470 nm : 680 nm

[Gatebe et al. 2003]
GOME-2 provides Lambertian Equivalent Reflectance (LER) over all scenes

MODIS Blue-sky albedo / GOME-2 LER comparison: Huntsville, AL

MODIS/GOME-2 mean difference over TEMPO FOR

Reflectance

Using MODIS or GOME-2 may provide similar shapes for the surface reflectance spectrum for 450-700 nm
Snow/Ice Scenes

Monthly GOME-2 LER over a snowy scene

[Graph showing reflectance versus wavelength for February, March, and April]

Measured Snow BRDF from CAR (680 nm)

Error from assuming Lambertian surface

[Two images showing BRDF for different wavelengths]

[Lyapustin et al. 2010]
Conclusions

- Surface Reflectance in the visible has strong variability (spectral, spatial, seasonal) which we need to capture for ozone profiling.

- 4 EOFs capture >99.5% of the spectral variation of surface reflectance from different land cover materials (400 – 900 nm).

- Fit EOFs to MODIS observed reflectance climatology (adjusted for viewing geometry) to generate high spectral resolution reflectance for use in TEMPO retrievals.

- Can use GOME-2 for scenes not covered by MODIS (snow/ice, water).