Sensitivity study of the MODIS cloud top property algorithm to CO$_2$ channel spectral response functions

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Outline of presentation

- CO$_2$ slicing approach -- MODIS cloud top property algorithm
- Intercalibration with AIRS suggests spectral shifts for the MODIS CO$_2$ channels
- Preliminary cloud top property results with shifted Spectral Response Function
- Summary
**Radiation Transfer Equation in CO₂ Slicing Algorithm**

Radiance from a partly cloudy FOV

\[ I_\lambda = \eta \varepsilon_\lambda I_\lambda^{bcd} + (1 - \eta \varepsilon_\lambda) I^{clr} \]

where \( \eta \varepsilon_\lambda \) = effective cloud amount (ECA)

\[ I_\lambda^{bcd} = B_\lambda[T(Pc)] \]
where \( B_\lambda \) = Planck function,
\[ T(Pc) = \text{temp at cloud top pressure } Pc \]

Two unknowns: \( \eta \varepsilon_\lambda \) and \( Pc \)
Two unknowns require two equations

\[
\frac{p_c}{ps} = \frac{p_s}{ps}
\]

Different ratios reveal cloud properties at different levels

hi - 14.2/13.9
mid - 13.9/13.6
low - 13.6/13.3

ECA is evaluated from the infrared window (IRW) band

\[
ECA = \eta \epsilon_{c(w)} = \frac{(I_{IR} - I_{IR}^{clr})}{(I_{IR}^{bd} - I_{IR}^{clr})}
\]
CO₂ channels see different levels in the atmosphere
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Aqua MODIS IR SRF overlaid on AIRS Spectrum
Images of 6 Sep 2002 descending MODIS brightness temperatures (left panels) and AIRS minus MODIS brightness temperature differences (right panels) for bands 36 thru 30.

*From Tobin et al 2005*
MODIS band 35
(13.9 µm) brightness temperature differences using original SRF (black) and using MODIS SRF shifted +0.8 cm⁻¹ (red)
*From Tobin et al 2005*

SRF shifted for CO₂ channels

- band 36: +1.0 cm⁻¹
- band 35: +0.8 cm⁻¹
- band 34: +0.8 cm⁻¹
- band 33: -0.15 cm⁻¹

show better agreement with AIRS for all temperatures
MODIS Weighting Functions with/without SRF shift (U.S. Standard Atmosphere)
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Study case 1:
Mid-Lat area
(1500UTC 2004336)
Aqua
Band 31
Calculated Clear Radiance vs. Observed Clear Radiance in Mid-Lat. for band 33, 34, 35, and 36
Upper: using original Spectral Response Function
Bottom: using Tobin’s shifted Spectral Response Function
Mid-Lat HI CTP with original SRF (left) and with shifted SRF (right)
Cloud retrieval method with original SRF (left) and with shifted SRF (right)
ECA with original SRF (left) and with shifted SRF (right)
ECA with original SRF (left) and with shifted SRF (right)
Study case 2: Tropical area (0320UTC 2004336)

Aqua Band 36
Calculated Clear Radiance vs. Observed Clear Radiance in Tropical area for band 33, 34, 35, and 36
Upper: using original Spectral Response Function
Bottom: using Tobin’s shifted Spectral Response Function
Maximum heights on edge of cloud

“Missing” cirrus

Spotty, noisy retrievals

Maximum heights on edge of cloud

Tropics HI CTP with original SRF (left) and with shifted SRF (right)
Cloud retrieval method with original SRF (left) and with shifted SRF (right)
Summary

• Comparisons of AIRS and MODIS radiance observations are applied at MODIS for cloud property retrievals

• Differences for MODIS band 34(13.6 µm), 35(13.9 µm), and 36 (14.2 µm) display clear and significant dependencies on scene temperature, shifted values for band 36: +1.0 cm⁻¹, band 35: +0.8 cm⁻¹, band 34: +0.8 cm⁻¹, and band 33: -0.15 cm⁻¹ are tested in MODIS Cloud Top Properties retrievals

• Detection of high thin cirrus is found to be sensitive to CO₂ channel spectral response functions

• In Mid-latitudes, MODIS CTP retrieval with shifted SRF find more high thin clouds, thick cloud edges problem is improved by shifted SRF

• In the tropics, SRF shifted results are not as good – more studies are needed