What happens in twilight zone: 3D or aerosol effect?

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-CERES-MODIS data show cloud and aerosol correlation.

-MISR data show reflectance increase approaching clouds.

-Possible reasons.

-Active measurement can avoid 3D and cloud contamination effect.

-Need advanced measurements in neighborhood of clouds.

-Summary.
Cloud and aerosol correlation: What’s the reason?

- Recent satellite studies have shown correlations between aerosol optical depth and cloud cover (Ignatov et al. 2005; Loeb and Manalo-Smith 2005; Kaufman et al. 2005; Matheson et al. 2006).

0.644-μm Aerosol Optical Depth vs Cloud Fraction (JJA 2000)

Loeb & Manalo-Smith (JCL, 2005)
MODIS Aerosol Optical Depth and Cloud Cover

Jim Coakley
Using MISR cloud mask and radiance data to see clear-pixel radiance as a function of distance from nearest cloud.

Cloud edge MISR viewing angle is saved.

Centered at clear pixels, the working window covers ~ 40 km x 40 km area.
MISR nadir reflectance as a function of distance from cloud

SZA = 25 - 35°

SZA = 35 - 45°

SZA = 45 - 55°

SZA=55-65°
Possible Reasons

- Aerosols are precursors to cloud formation.
- Aerosols grow in humid environments near clouds.
- Aerosols grow through in-cloud processing.
- New particle production in the vicinity of clouds.
- Illumination of particles enhanced by scattering of sunlight by clouds.
- Cloud contamination of the cloud-free pixels used to obtain aerosol properties.

Clearly, what happens to aerosols in the vicinity of clouds needs to be understood.

Jim Coakley
3D radiative enhancement results in an overestimate of AOD of 0.04 in 1-D retrieval

Wen et al. 2006
Active measurement can avoid 3D and cloud contamination effect

Airborne HSRL

CALIPSO

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NASA Langley B200 King Air HSRL MILAGRO March 13, 2006

Airpool Backscatter Coefficient (532 nm) (km-m)\(^{-1}\)\(\times\)10\(^{-10}\)

Longitude(deg)
What does CALIPSO attenuated scatter show?

CALIPSO attenuated scatter profiles at different distance from cloud. Red: far; Green: near; Blue: cloud.
Averaged CALIPSO attenuated scatter profiles at different distance from cloud. Red: far; Green: near; Blue: cloud.
CALIPSO can show large-scale and significant cloud / aerosol process

**CALIPSO First-Light Observations**

9 June 2006

532 nm Total Attenuated Backscatter, /km/sr

532 nm Perpendicular Attenuated Backscatter, /km/sr

1064 nm Attenuated Backscatter, /km/sr

Fire locations in southern Africa from MODIS, 6/10/06
Airborne High Spectral Resolution Lidar (HSRL)

- Focused on providing quantitative measurements of aerosol optical properties
- Different from standard backscatter lidars: independently measures backscatter and extinction (532 nm)

**History**
- 2000-2004: instrument development and integration
- Dec 2004: first test flight on Lear 25-C
- Dec 2005: first test flight NASA Langley King Air
- >200 flight hours with instrument since completion, including
  - 60 hours on MILAGRO/MAX-MEX
  - 45 hours on CALIPSO validation (East US)
  - 90 hours on 2006 TexAQS/GoMACCS/MAX-TEX
Airborne High Spectral Resolution Lidar (HSRL) may work for twilight zone

LaRC Airborne HSRL Measurements over Mexico City, March 13, 2006
- western part of city - high $S_a$, high WVD, low depolarization – urban aerosol
- eastern part of city - low $S_a$, low WVD, high depolarization – dust

Chris Hostetler
Need advanced measurements in neighborhood of clouds

Proposal: Using circularly-polarized airborne LIDAR to measure P11 and P44 to see transition of particle shapes and sizes when approaching cloud

Measure I & V for particle shape & size

V / I = P44 / P11

If there is no shape & size change: No swelling
Otherwise: Swelling

Fig. 2. The non-zero elements of the scattering phase matrix as functions of scattering angle calculated with the FDTD technique for randomly oriented Gaussian particles illustrated in Fig. 1. The incident wavelength \( \lambda = 0.55 \) \( \mu \text{m} \) and the refractive index of ice at this wavelength is \( N = 1.311 \). The particle size parameter \( x = 2a/\lambda = \pi \), where \( a \) denotes the mean radius of the particle. In the FDTD calculation, a spatial cell size of \( \lambda/20 \) is used.
Summary

1. Satellite data suggest aerosol-cloud correlations: Cloud cover increases with aerosol optical depth.

2. In the neighborhood of clouds, 3D cloud radiation effect, undetected cloud, and aerosol humid swell all can affect aerosol retrievals, and contribute to aerosol-cloud correlations.

3. Using active measurements can avoid 3D effect and detect clouds missed in passive measurements.

4. How to separate humid swelling effect and indirect effect?
Presentations in CERES TOA Flux/ADM WG Meeting

1. Using CERES Window Data to Validate Diffusivity Approximation Theory
   Wenbo Sun, Yongxiang Hu, Norman G. Loeb, Bing Lin, and Marty Mlynczak

2. Can DISORT Simulate Reflectance from Snow?
   Wenbo Sun and Norman G. Loeb
Comparisons of the window fluxes for (a) clear sky, (b) overcast clouds, and (c) all-sky, from the diffusivity approximation theory and CERES WN ADMs for 31 days of January 2005 for latitudes between 75 deg S and 75 deg N. The color bar shows the occurrence frequency of the samples.
When distance increases
More peaks are expected, i.e. more Lambertian.

When distance decreases
fewer peaks are expected, closer to rough surface scattering