3D Cloud Effects as Seen From MISR

progress towards retrieving large optical depths

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outline

- improvements to the local estimator method
- intercomparison examples of our 3D Monte Carlo model
- methodology of retrieving optical depths of deep convective cloud
- geometric reconstruction of convective cloud
- comparisons between model and observations
directional Monte Carlo
solid angle Monte Carlo
• enhanced adding-doubling
3D Monte Carlo model
multi-angle approaches to $\tau$

- using MISR for example
  - 9 pushbroom cameras
- nadir $\pm 26^\circ$ views for stereo
  - cloud geometry (top and side)
- $45^\circ$–$70^\circ$ views of side reflectivity
- approach 1: match full 3D
  - Zuidema et al., JGR ‘03
- approach 2: gradient analysis using a reciprocal TIPA (tilted independent pixel approximation) approach
MISR high resolution imagery

nadir image
MISR high resolution imagery

60° oblique image

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static views from nadir and oblique views of the An unusual cloud east side

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analysis

- cloud geometry
  - $\approx 5$ km wide
  - $\approx 10$ km deep
- reciprocal TIPA analysis:
  - $\tau_h > 25$, $\tau_v > 100$
  - $\beta$ (ext. coeff.) $> 5$–$10$ km$^{-1}$
- gradient analysis of unsaturated $\tau$
  - $\beta \approx 8$ km$^{-1}$ at top, $\approx 22$ km$^{-1}$ at base
retrieval summary
importance of cloud phase

Most deep convective clouds are glaciated

Extinction coefficient and scattering phase function

Water and ice differ significantly

The retrieval of LWP (or ice water path) requires

Knowledge of the vertical transition region between

Liquid and ice is frequently present, so that

Phase-phase relations are not reliable between

-30°C to 0°C (even if the brightness temperature

Satellite are known)

Detect ice vs. liquid phases using a split

In the solar infrared and use the

Cloud phase to derive the correct LWP

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the imaginary index of refraction for liquid water has a turning point at ≈1670 nm, whereas the index for ice changes steadily with wavelength

the above figures, from Knap et al. 2002, show the effect on cloud reflectivity

Knap* has demonstrated that this can be used as a useful detector of cloud phase, using spectrally resolved radiances around 1670 nm

CHASM will measure spectral reflectivity in two adjacent bands (1655 nm and 1685 nm)
radiances modeled at cloud boundary
examples of angular distribution
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