Considerations of Habit Effect in the retrieval of ice cloud properties using satellite data

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ABSTRACT

Uncertainties in radiative properties caused by ice crystal habits are significant, whose impacts are not restricted to remote sensing. This uncertainty influences areas such as ADM, cloud parameterization and results of in situ measurements. We have used different approaches to investigate ways of narrowing the uncertainties of ice crystal habits. The results show that the CERES biaxial data is a very promising candidate.
A wide variety of ice crystal shapes exists in ice clouds.
Significant advances have been made in calculating radiative properties of non-spherical particles.

Yang et al. (1996)

- The problem is when to use which habit in applications.
Variations in Habits cause difficulties in Remote Sensing (I)

- Uncertainties in retrieved optical thickness is a factor of 3~4

Mishchenko et al. (1996)
Habit assumption leads to uncertainties in Remote Sensing (II).

- Uncertainties of retrieved size using 8 and 11 \( \mu m \) are large.

Baran et al. (1998)
Habit assumption leads to uncertainties in Remote Sensing (II)

- Uncertainties of the retrieved $r_e$ using 1.6, 2.2 and 3.7 $\mu$m
What are habit assumptions used in satellite retrievals?

**ISCCP**

Rossow et al. (1996)

**POLDER: Modified VVP** (Doutriaux-Boucher et al. 2000)

**MODIS**

- D<70 µm: 25% 25% 50%
- D>70 µm: 30% 20% 20% 30%

Baum et al. 2000

- In all algorithms, one habit assumption is used for all ice-clouds
Habit variations in mid-latitude regions

- Even for midlatitude, the habit variation range is large
Habit Influence on the downward net flux density

- The uncertainties of downward net flux density for given $r_e$ are around 200 W/m²

(Chou 2002)
$r_e$ as a function of different habit for 30 sample cloud models.

- Different assumptions of habits lead to different $r_e$
- Using sample cloud models leads to multiple solution in $r_e$
Comparison of particle size for two definitions

- Cloud parameterization schemes are habit specific

McFarquhar (2001)
Anisotropic factors for a given $\tau$ and $r_e$

For the two common habits, the range of variation in anisotropic factors is larger than that caused by optical thickness.
Can we detect crystal habits?
- Degree of Polarization (I)

Mishchenko and Honevier (1995)

- DOP is not a good indicator of particle shapes for small sizes
Can we detect crystal habits?
- Degree of Polarization (II)

- DOP measurement may distinguish smooth and rough particles at certain angles
Can we detect crystal habits?
- Multiangle observations (I)

- Dual angle observations are used to distinguish polycrystals
- All crystals are assumed to be the same habits

Baran et al. (1998)
ATSR data
Can we detect crystal habits?
- Multiangle observations (II)

- Similarities of signals in dual angles of ASTR restrict the ability of detecting crystal habits
Can we detect crystal habits?
- Multiangle observations (III)

- Reflections at backscattering direction are significantly affected by particle shapes.
Can we detect crystal habits?
- Multiangle observations (IV)

• Multiangle observations enable more details of particle shape detection
Summary

• Uncertainty caused by particle shapes has impacts on remote sensing as well as on ADM, cloud parameterization and results of in situ measurements. Information of crystal habits is critical in these fields.

• The CERES biaxial data is a promising candidate for developing such an ability.