Global statistics of microphysical properties of cloud-top ice crystals

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NASA grant # NNX14AI28C

Ice properties are important for radiation, cloud evolution, precipitation efficiencies, etc. Ice properties are known to vary with, e.g., temperature, humidity (see Fig. on left and below), and ice nucleation availability. Determining such relationships in the complex atmosphere remains elusive.

Ice crystal shape characteristics mostly determine phase functions:
1. Aspect ratio of crystal components (meso-scale)
2. Surface roughness, distortion, impurities or cavities (micro-scale)
3. Habit (macro-scale)

We focus on micro- and meso-scales since they are far more important than the macro-scale (habit). Also, "habit" is not quantifiable. Simple hexagonal plates and columns are used as proxies for complex ice.

3. Shape and asymmetry parameter retrieval approach

Aspect ratios and roughness of proxy hexagonal prisms are retrieved by matching multi-angle polarization reflectance at 120°-150° scattering angles with a model. The relation between polarization and aspect ratio and roughness can be seen on the right.

The asymmetry parameter is uniquely determined by aspect ratio and roughness as seen below.

4. Data

- POLARIS-MODIS collocated data at 36 km resolution for 2007
- MODIS collection 6 ice effective radius and optical thickness and height
- Consistent ice cloud fiber: POLARIS-MODIS phase index = extra rainbow detection phase index

6. Global distribution of average optical thickness of ice clouds with e=5

High, cold clouds
Lower, warm clouds

7. Yearly-averaged global distribution of cloud-top properties

Effective radius
Asymmetry parameter
Aspect ratio
Roughness

8. Seasonal variation of profiles (for ice clouds over ocean with e=5)

9. General tendencies

10. Implicated % bias on MCD16G retrievals from constant asymmetry parameter

MODIS collection 6 retrieves assume an ice model with an asymmetry parameter of 0.754 in the visible.

When the real asymmetry parameter is, e.g., this assumption creates biases of (1-s)/(1-0.754) = 1.00%, as seen below. Maps on the right show average biases.

References