Assessing the effect of satellite viewing geometry on retrieved ice cloud particle surface roughness using MISR satellite observations

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ABSRACT

The Multi-angle Imaging SpectroRadiometer (MISR) instrument measures reflectivity at nine angles along the satellite track. For the each measured reflectivity, estimated spherical albedo are computed based on results of radiative transfer calculation with randomly oriented hexagonal ice particle model and chosen roughness values. The spherical albedo difference (SAD) is defined as the difference between estimated spherical albedo at any angle and the average of them. If the assumed roughness is correct, SAD values should be close to zero at all scattering angles. By analyzing SAD values as a function of solar angles and latitudes, we estimated the effect of satellite viewing geometry on retrieved ice particle surface roughness. The angular profiles of SAD values are calculated in different latitude bands on December and June solstice days.

1. BACKGROUND and METHODS

Background

Ice cloud particle surface roughness is one parameter in ice cloud models to improve the consistency between observations and light scattering calculations. Retrieving the degree of ice particle surface roughness is helpful to improve the consistency of retrieved optical thickness between MODIS and CALIPSO datasets (Holz et al, 2016).

Strategy

We applied the method described by Doutriaux-Boucher et al. (2000) to MISR multi-angle dataset to retrieve spherical albedo difference (SAD) values. SAD values are computed for 12 degrees of roughness (ranging from $\sigma^2 = 0$ to $\sigma^2 = 3.50$), using hexagonal column aggregate shape (Yang and Liou,1998).

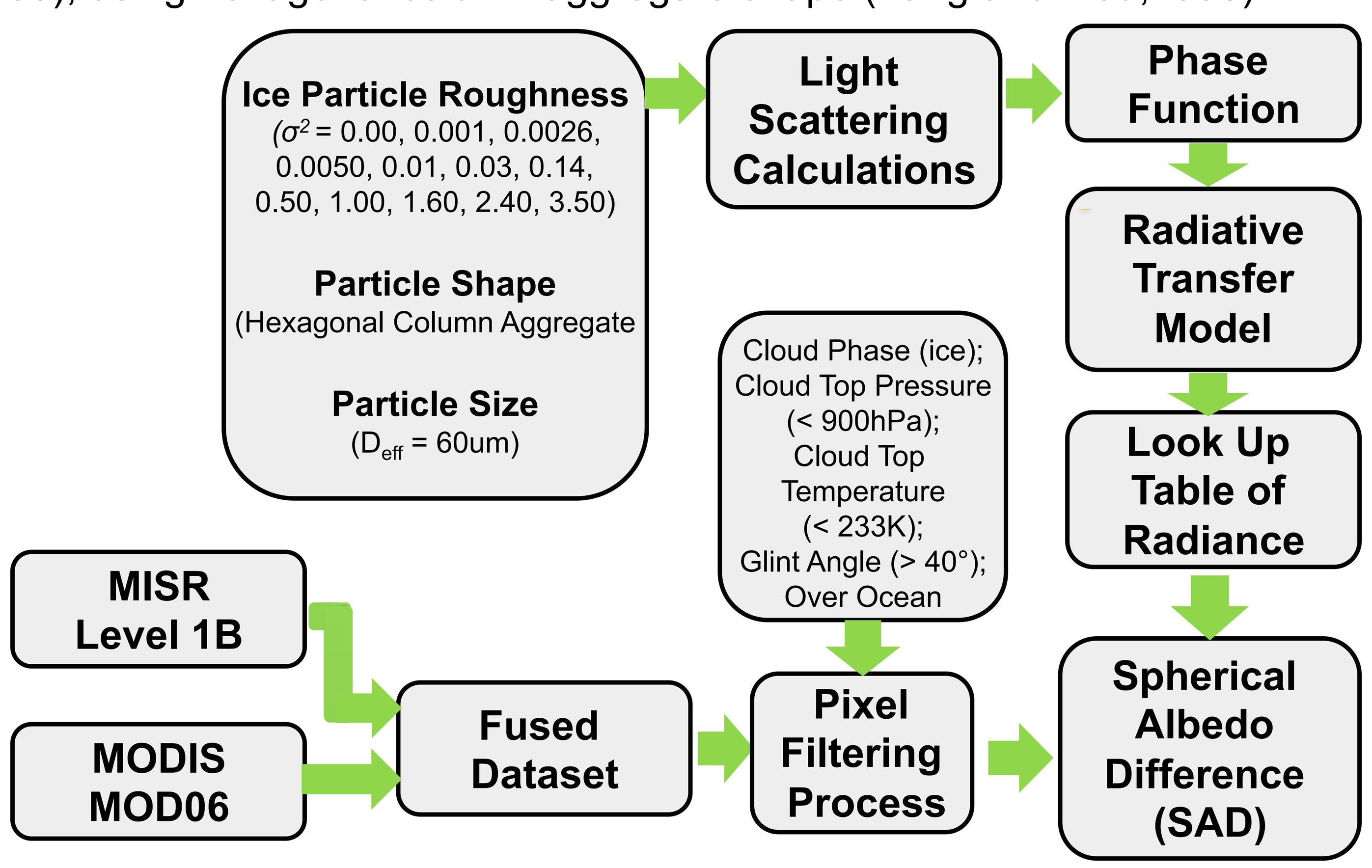

Fig. 1. Data flow of ice cloud particle surface roughness retrieval.

Then, a best-fit approach was used to determine each pixel's optimal degree of roughness. The best degree of roughness achieves the minimum sum of square of 9 SAD values corresponding to 9 cameras among all degree of roughness.

Scientific Questions

- What is the global distribution of degree of ice particle roughness by using SAD analysis and best-fit approach?
- Is retrieved degree of roughness independent of satellite viewing geometry?

2. GLOBAL DISTRIBUTION

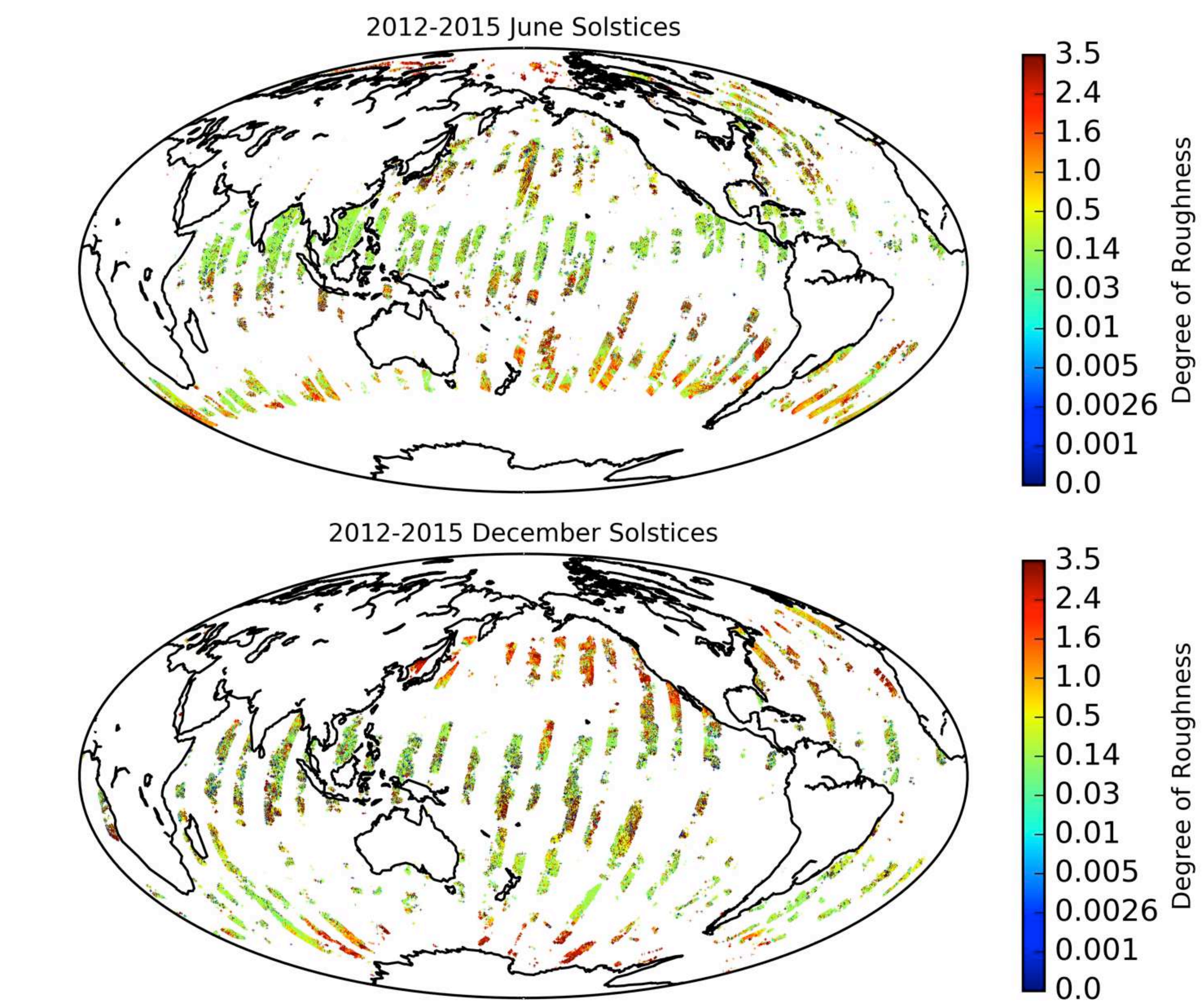

Fig. 2. Global distribution of retrieved degree of ice particle surface roughness for 2012 - 2015 June solstices (upper) and December solstices (bottom) using Spherical Albedo Difference (SAD) analysis and the best-fit method.

The degree of roughness in both of these two figures show latitudinal distributions primarily.

3. LATITUDINAL DISTRIBUTION of SAD

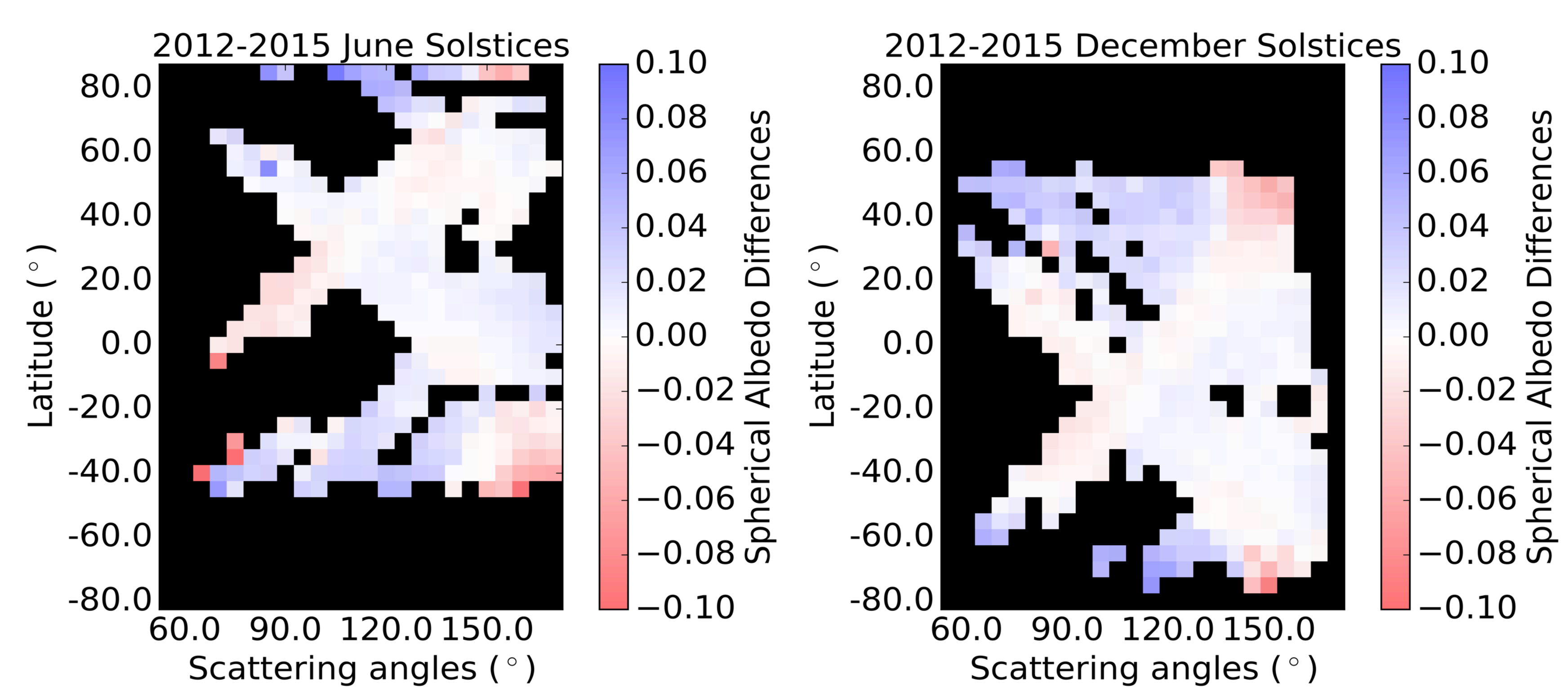

Fig. 3. The angular profiles of Spherical Albedo Difference (SAD) in different latitude bands on 2012 - 2015 June (left column) and December (right column) solstices. The assumed degree of roughness is 0.14. Black area denotes no available data.

The SAD profiles shift with data sampling pattern (solar zenith angle), and is not fixed at latitudes.

In low and mid solar zenith angle (SZA) region (center of non-black area), ice particle model (σ^2= 0.14) performs better than at high SZA region (top and bottom of non-black area).

4. FRACTION of EACH ROUGHNESS

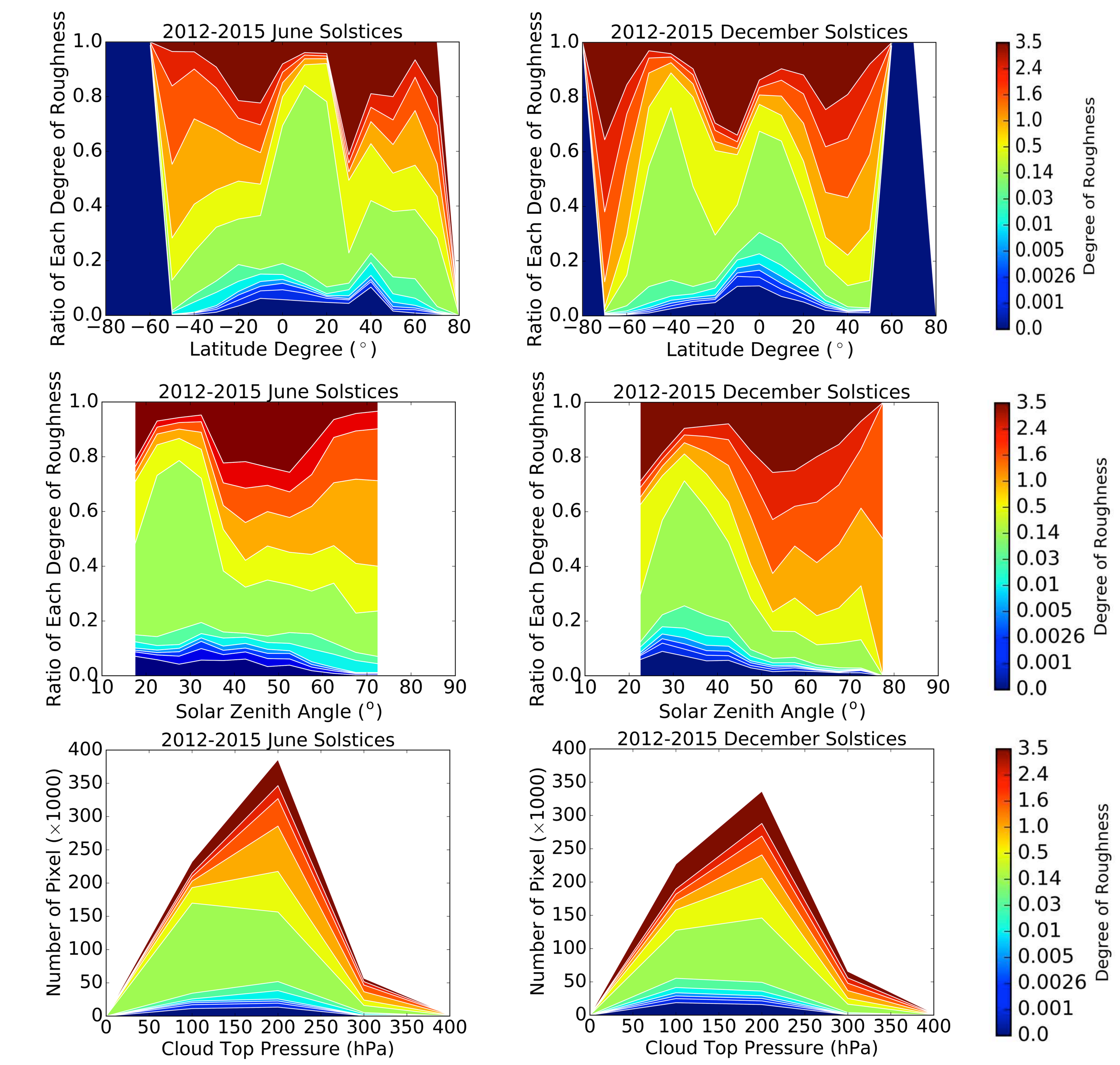

Fig. 4. Fractions of ice particle surface roughness by latitude (top row), solar zenith angle (middle row), and cloud top pressure (bottom row) during 2012-2015 June solstices (left column) and December solstices (right column).

The most popular retrieved degree of ice particle roughness is $\sigma^2 = 0.14$.

The peak of contribution by $\sigma^2 = 0.14$ is at 10°N on June solstice days, whereas at 10°N and 50°S on December solstice days. However, distributions of SZA have only one peak in both solstices.

The 200 hPa is the most popular cloud top pressure in the retrieved global ice cloud particle.

5. CONCLUSIONS

- The degree of roughness is primarily a function of latitude during both December and June solstices from 2012 to 2015 based on the results using SAD analysis and the best-fit method.
- The most prevalent retrieved degree of ice particle surface roughness is 0.14.
- The distribution of SAD and degree of roughness more align with solar zenith angle than with latitude.
- The roughened ice particle model ($\sigma^2 = 0.14$) performs better at low SZA region than high and mid SZA region.

REFERENCES and ACKNOWLEDGEMENTS

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