The Influence of Spatial Resolution on the Inference of Ice Cloud Particle Morphological Parameters from Multi-angle Satellite Observations

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Abstract

Space-borne multi-angle observations provide valuable information that help select an ice particle model for operational cloud property retrievals. We attempt to estimate the influence of spatial resolution of such multi-angle data on the inference of particle surface roughness. A simple inference scheme that is similar to the spherical albedo difference techniqiue is developed, and applied to a block of data from the Multiangle Imaging SpectroRadiometer (MISR) sensor on the Terra platform. In the tested tropical cirrus scene, slight resolution dependence is detected near the satellite ground track. Further study is needed to identify if this is caused by the viewing geometry or the local cloud heterogeneity.

1. Background and Strategy

The ice particle surface roughness is a parameter of an ice cloud model to mimic the disturbed symmetry and imperfections within an ice particle. Previous studies indicate that the application of surface roughness in the light scattering computation improves the consistency between modeled and observed reflectivities.

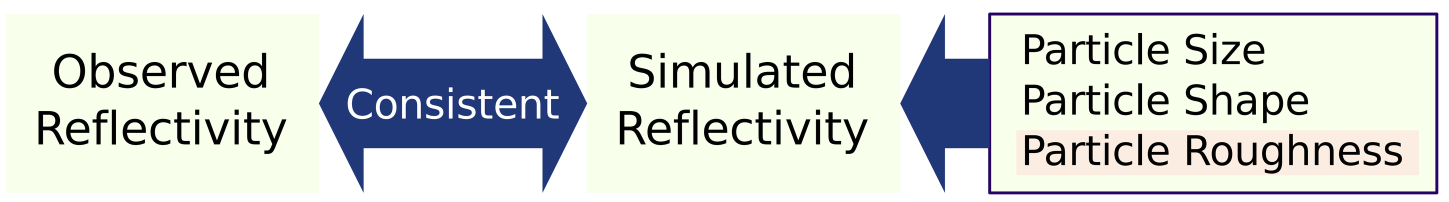


Fig. 1. Required consistency between observation and simulation.

A common approach to validate the consistency uses multi-angle satellite observations at visible wavelengths (e.g. Baran and C-.Labonnote, 2006). However, radiances from multi-angle sensors are strongly influenced by cloud top structures and heterogeneities (e.g. Horváth and Davies, 2004).

Scientific Question

Is the inference of the representative roughness parameter influenced by the resolution of the multi-angle sensors?

Our Strategy

1. Average the radiance from the Multi-angle Imaging SpectroRadiometer (MISR) sensor at different spatial scales.
2. Compute apparent spherical albedo (ASA) values from the averaged radiance for every MISR camera and pixel.
3. Select the surface roughness parameter that minimizes the inter-camera variance of ASA as the most representative value for a given pixel.

Fig. 2. The scientific question to be addressed and our strategy.

2. Data and Methods

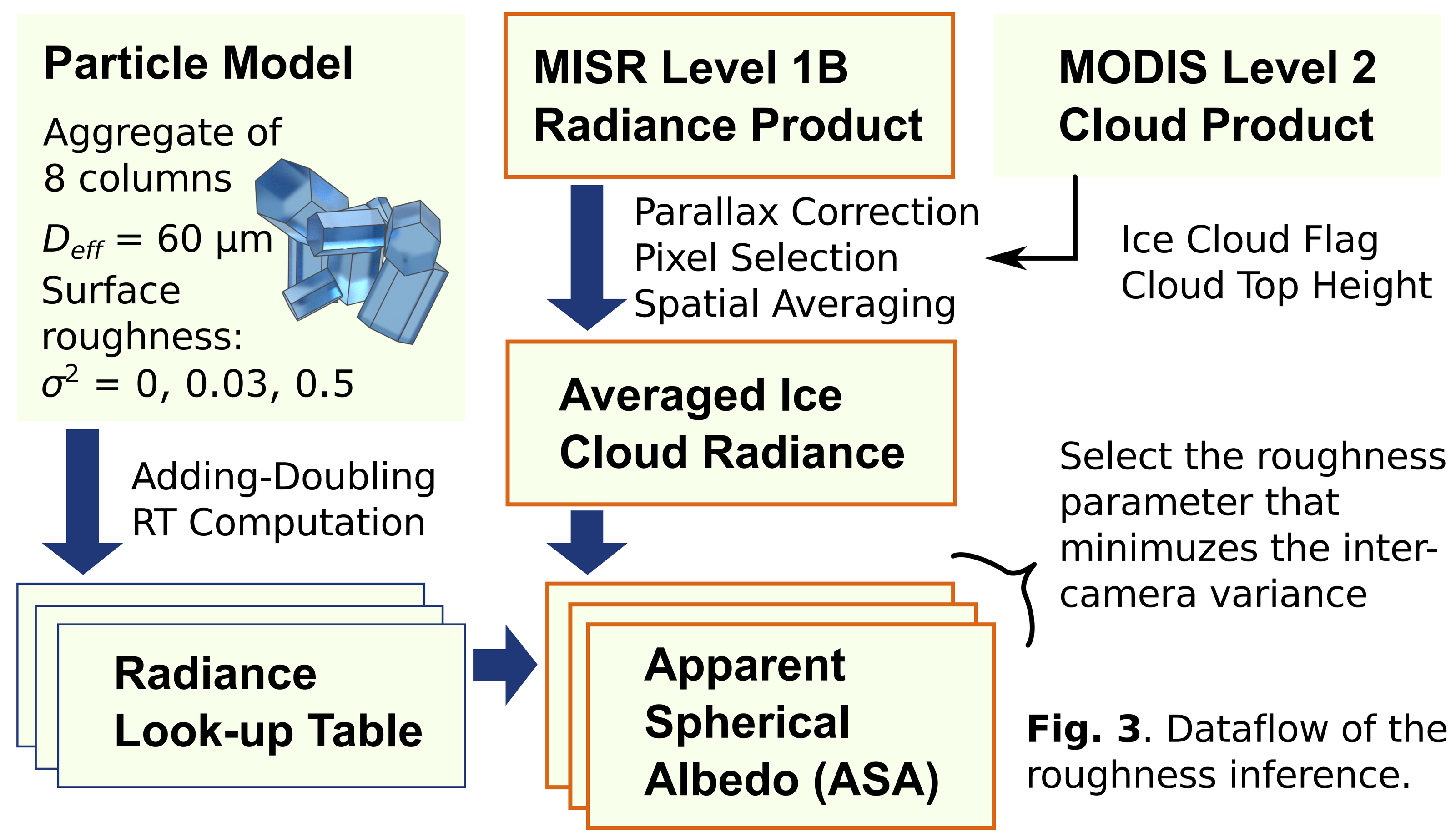
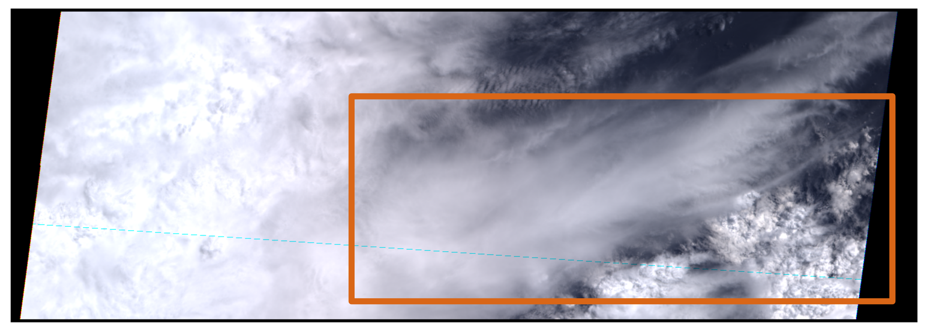


Fig. 3. Dataflow of the roughness inference.

3. Spatial Pattern



Orbit : 73111
Block : 99
Time : 20:55Z Sep. 15, 2013
Location: Tropical South Pacific (10°S, 160°W)

Fig. 4. True color composite from MISR radiometric product.

The result of the roughness parameter inference from the MISR data shows a consistent pattern throughout different scales of spatial averaging, while synthetic data with a fixed roughness parameter converges to the uniform result.

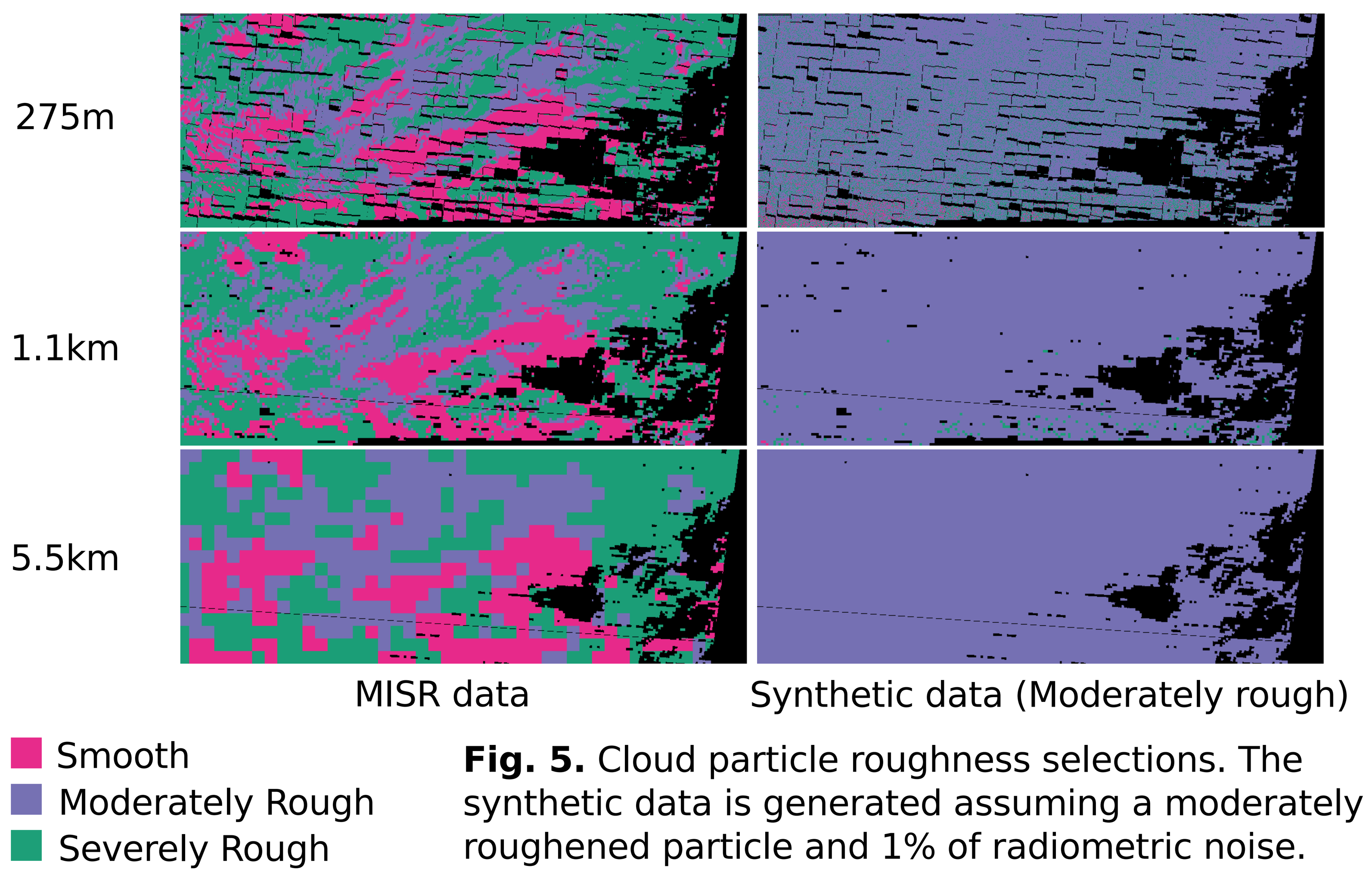


Fig. 5. Cloud particle roughness selections. The synthetic data is generated assuming a moderately roughened particle and 1% of radiometric noise.

4. Resolution Dependence

Using the same MISR data used in Section 3, the averaging scale is varied from 275 m (original resolution) to 6 km (22 x 22 pixel). The resolution dependence is not evident.

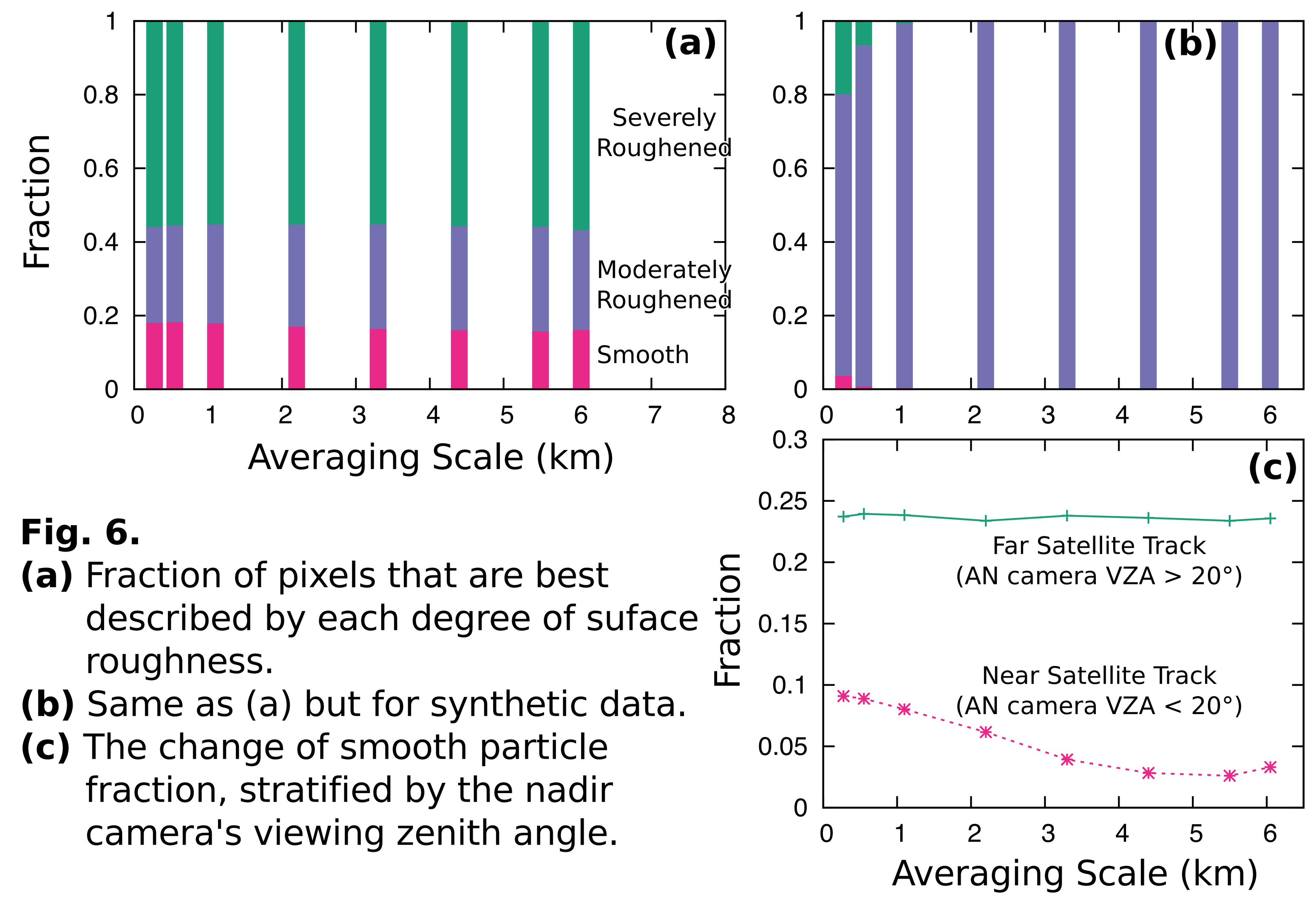


Fig. 6.
(a) Fraction of pixels that are best described by each degree of suface roughness.
(b) Same as (a) but for synthetic data.
(c) The change of smooth particle fraction, stratified by the nadir camera's viewing zenith angle.

5. Summary and Discussion

A simple roughness parameter inference is attempted with the MISR data. The results show a spatial pattern that is similar to the cloud reflectivity. For the tested MISR block (cirrus clouds near convection) optically thick parts of clouds tend to be best-explained with smooth particles.

The 1% radiometric noise can disturb the inference of the surface roughness parameter at high resolutions (pixel size < 1km). At 275 m resolution, the misclassification rate can reach up to 20%.

For the tested MISR block, no significant resolution dependence of the inferred surface roughness values was found. Detailed investigation showed a slight decrease of smooth particle fraction near the satellite ground track. Further study is needed to investigate if this is because of the viewing geometry or morphological structure of clouds.

References and Acknowledgments

- Baran and C.-Labonnote (2006), *J. Quant. Spectrosc. Radiat. Transf.*, **100**, 41-54
- Horváth and Davies (2004), *Geophys. Res. Lett.*, **31**, L01102

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