Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2019-216-RC2, 2019
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Atmospheric Measurement Techniques Discussions

Interactive comment on "Toward autonomous surface-based infrared remote sensing of polar clouds: Retrievals of cloud microphysical properties" *by* Penny M. Rowe et al.

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Received and published: 9 July 2019

This manuscript builds on earlier work (Rowe et al. 2016; cloud height retrieval) to include the inference of cloud optical and microphysical properties (optical thickness and particle size), which also requires cloud thermodynamic phase. The current methodology now includes consideration of cloud phase, vertical inhomogeneity, ice habit, sensor noise, and more, in an optimal estimation framework. Good use is made of the ice particle single-scattering property database of Yang et al. (2013). Their interest is the examination of the retrieval sensitivity to spectral resolution from 0.1 to 8 cm-1. As noted in the Abstract, the retrieval accuracy is basically unaffected by resolution from

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Discussion paper

0.1 to 2 cm-1 and decreases slightly as the resolution increases thereafter. The stated goal is to work towards autonomous surface-based IR remote sensing of polar cloud properties by a portable spectrometer system.

The methodology is clearly stated, adequate references are made to work by earlier studies although more recent articles may be available, and the analyses are straightforward. I am glad to see that the software is being made available to the community as described in Section 7. My view is that the paper is suitable for publication pending relatively minor revisions that address the comments that follow.

If there is one primary suggestion to offer, it would be to compare the cloud properties obtained by this method to those obtained from CALIPSO, where new Version 4 products are now available (or to a coincident ground-based lidar if possible). Of particular note is that the V4 products have significant improvements in calibration and cloud/aerosol properties. There will be differences between satellite- and surface-based products that will bear further investigation, but this may be outside the scope of this particular study. CALIPSO cloud products have been used heavily in the development and testing phase of many satellite-based cloud retrieval efforts, especially with the discrimination of cloud thermodynamic phase which is a critical component of the current study. As noted in Section 5.4, imperfect cloud phase discrimination can greatly increase the retrieval errors (lines 500-505).

General comments:

Lines 58-62: Two points to suggest here: 1. The authors point out the need for portable, low-cost, autonomous IR spectrometers that can make continuous measurements. But these measurements complement those from polar-orbiting IR spectrometers including IASI (on Metop-A/B/C), AIRS, and CrIS. It would be useful to provide an example where the surface measurements fill the gaps between satellite overpasses. 2. Additionally, a primary benefit to surface-based measurements is that the boundary layer is much better characterized than with profiles inferred from a satellite-based spectrometer. In

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particular, my impression is that the boundary layer profiles are much improved when temperature inversions are present, and this will impact the cloud properties if the layer is at/below the inversion.

Section 3: This is a long section (over 6 pages) that discusses the Cloud and Atmospheric Radiation Retrieval Algorithm (CLARRA) in quite a bit of detail. Cloud height was discussed in great detail in Rowe et al. (2016) and is not repeated herein. Perhaps the readability would be improved by moving much of the theoretical development into an Appendix.

Minor comments:

Line 19: please define exactly what is meant by “mixed phase” - is it a homogeneous mixture of ice and liquid particles or something else?

The word “infrared” appears 26 times in the paper - could contract to IR

Line 47: include more up-to-date L’Ecuyer papers, e.g., “Reassessing the effect of cloud type on Earth’s energy balance in the age of active spaceborne observations. Part I: Top-of-atmosphere and surface”, by TS L’Ecuyer, Y Hang, AV Matus, Z Wang, in Journal of Climate, 2019. There is also a Part 2 manuscript in review.

Lines 293-294: Radiances are selected in two bands: 400 to 600 cm-1 and from 750 to 1300 cm-1. As the method is using selected wavenumbers for each chosen spectral resolution, it would be useful to state them in this paper rather than in the supplemental.

Lines 340; 352; 557: suggest changing “in order to” to “to”

Line 356: change “found such error” to “found such errors”

Lines 503-505: Cloud height: is CO2 slicing used for both water and ice clouds? If so. . ..might want to change this so it’s used primarily for ice clouds and use 11-μm for optically thick clouds.

Line 536: Polar Regions does not have to be capitalized.

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Line 561: suggest changing “correctable” to “mitigated”

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