

Interactive comment on “Remote sensing the vertical profile of cloud droplet effective radius, thermodynamic phase, and temperature” by J. Vanderlei Martins et al.

Anonymous Referee #2

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The authors describe a very interesting and novel approach for remotely sensing the vertical profiles of the droplet effective radius, the thermodynamic phase as well as of the temperature through individual cloud elements from ground-based, airborne or spaceborne multi-wavelength cloud scanning radiometer measurements.

While the scientific applications of the proposed idea have very high priority, it seems that several aspects with respect to the feasibility of the described approach are unclear. It is requested that the authors address in their revised manuscript the major points described next.

General comments to be addressed:

1) Please describe briefly the instrumentation employed in the CLAIM campaign. Make reference to any available CLAIM publications, either in journals, or, if not available, at least refer to relevant web pages.

2) The cloud side scanning geometry implies that the instrument records solar photons predominantly in the backscattering direction. Scattering phase functions for individual spherical and non-spherical water or ice particles do differ particularly in the side and backscattering directions. Given a fixed amount of cloud water or cloud ice, how big is the influence of particle shape on the reflected radiation? Have any sensitivity studies been performed by the authors with respect to this issue?

3) Feasibility assessment of radiometrically scanning the side faces of realistic clouds. Which portion of a typical cloud scene does allow "visible access" to the cloud sides? Certainly, cirriform and all types of stratiform clouds would not be candidates to be observed. What would happen in a situation for which individual clouds are located above a lower cloud layer? Would cirrus clouds located above a particular cloud target hamper the retrieval of the vertical profiles of effective drop radius and temperature?

4) Most likely, the cloud scanning instrument would be not the only instrument on the proposed platform. Please discuss other instrumentation that would provide complementary information.

5) The side viewing geometry needs a retrieval algorithm that converts all slant views to altitude or pressure levels in a consistent manner. It is not clear to the reader how this can be achieved, i.e. how can the distance between the detector to a particular area element on the walls of an individual cloud be measured accurately? Note that the satellite will be typically 800-1000 km away from the cloud, while the aircraft's view in Fig. 7 was just 20-30 km away from the target.

Specific comments:

6) p. 4487, last paragraph of the Introduction: Reference is made to the "current model

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of the cloud scanner". Please provide more detail on this instrument with respect to: i) calibration issues for wavelength accuracy, ii) absolute radiometric accuracy, iii) accuracy of measured spectral reflectance, iv) signal to noise ratio versus wavelength, v) calibration of radiances in thermal atmospheric window region, vi) spatial resolution. - Please also elaborate on the time resolution of the scanning instrument versus the platform velocity.

7) p. 4490, lines 16-20: It is stated that the conventional geometry of making cloud-top nadir reflectance measurements has to rely on certain assumptions, for example, that the observed or retrieved quantities at a certain point/altitude within the cloud is to be taken as valid for all points within this cloud having the same altitude. It is not clear, which assumptions have to be employed in order to interpret the proposed cloud side scanning observations. Please explain this issue in more detail, since any cloud, when viewed from the side, is not transparent in the entire visible to thermal infrared wavelength region.

8) p. 4491, lines 8-14: Reference is made to the penetration depth of near infrared wavelengths. Please quantify the "domain of influence" within the cloud for the measured cloud side radiances. Please give some examples for photons having different near infrared wavelengths to make the capabilities of the cloud scanning instrument with respect to vertical resolution more illustrative.

9) p. 4492, lines 3-8: Reference is made to the uncertainties of ground-based observations with respect to large background noise as related to water vapor emissivity effects or cloud shadow effects. But, any particular observation geometry has its strengths and weaknesses. For example, for spaceborne observations both shadow effects as well as uncertainties with respect to surface temperature and water vapor may negatively influence the spectral cloud side scanning observations, too. The authors are asked to comment on this and to provide clear arguments supporting the proposed strategy.

10) p. 4493, lines 5-7: One particular point to be discussed in this context is the

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fact that real clouds have no such smooth vertical side walls like those used for the SHDOM simulations, i.e. idealized cylinder clouds. Please describe the uncertainty of associating slope information and/or gradient information $-df/dx$ to altitude dependent quantities like retrieved temperature and retrieved effective drop radius.

11) p. 4498, lines 16-18: Here describe the accuracy of the calibration for the 2.1 μm cloud reflectance. A further explanation needed in this context is a brief paragraph describing the main steps and assumptions employed for retrieving the profile of the effective drop radius.

12) p. 4500, lines 24-26: Here the authors discuss the match and mismatch of the refractive index for ice in Fig. 8. Frankly speaking, the used argument is very much guesswork. There are several other unknowns influencing the reflectance behaviour of ice cloud particle populations. For example, the observation angle versus the solar incidence direction (solar zenith angle and solar azimuth angle) along the outer faces of the cloud may have a very strong impact, too. Please discuss possible cloud orientation effects. Indeed the real cloud shown in Fig. 7 does not resemble the cylinder idealization.

Typographical errors in the manuscript:

- p. 4482, line 28: change to "... multi-angle polarization ..."
- p. 4483, line 17: change to "... was Twomey's theory (1977) in which ..."
- p. 4484, line 4: change to "... Hansen et al. (1997) showed that ..."
- p. 4484, line 5: change to "... absorbing aerosols can effectively ..."
- p. 4484, line 18: change to "... 2006a) have been introduced ..."
- p. 4485, line 13: change to "... and give information on the ..."
- p. 4485, line 16: change to "... (e.g., Frisch et al., 1995) ..."

- p. 4486, lines 15-18: use “,” at end of first item, and use “.” at end of second item
- p. 4490, line 9: change to “... of different heights has been provided ...”
- p. 4495, line 3: change to “... analogue corresponds to a case ...”
- p. 4496, line 2: change to “... approach to provide ...”
- p. 4496, line 15: change to “... vary substantially along the path of a horizontally flying aircraft ...”
- p. 4496, line 22/23: change to “... Rosenfeld and Woodley (2006b), who show that ...”
- p. 4496, line 28: change to “... diameter of the droplets remains constant ...”
- p. 4497, line 14: change to “... The right panel exemplifies the result ...”
- p. 4498, lines 25-27: change to “... becomes even more efficient after ... processes take over.”
- p. 4499, lines 4-5: change to “... newly formed ice crystals, due to precipitation ...”
- p. 4499, line 16: change to “... in these wavelengths comes from ...”
- p. 4500, line 14: change to “... still produces very strong and unambiguous signals.”
- p. 4502, lines 18-19: change to “... and points to the role of remote sensing ...”
- p. 4502, line 21: change to “... Glory satellite ...”
- p. 4504, line 9: change to “... multi-angle polarization ...”
- p. 4511, Fig. 3, line 1: change to “... performed from high altitude ...”
- p. 4513, Fig. 5, line 5: change to “... as shown in the legend ...”
- p. 4514, Fig. 6, lines 5-7: change to “... the left panel represents ... The same solid red line is shown on the right panel of the figure. ...”

p. 4517, Fig. 9, line 1: change to "... shows "the general case" effective radius ..."

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 4481, 2007.

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