

***Interactive comment on* “Determination of optical and microphysical properties of thin warm clouds using ground based hyper-spectral analysis” by E. Hirsch et al.**

Anonymous Referee #2

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This paper uses a new technique to retrieve effective radius and liquid water path from ground-based IR spectral measurements for thin clouds (optical thickness below 5). The sensitivity to thin clouds is achieved by subtracting the background spectrum, and by matching the difference between cloud-spectrum and background spectrum to a pre-calculated library of differential spectra. It seems that the paper has many figures that are based on calculations, rather than actual data. Out of 24 Figures, only 2 (Fig 23 and 24) show actual data. A figure with a measured sample spectrum, after all the basis for the retrieval algorithm, is missing. Similarly, the instrument itself and its performance, calibration, stability etc. is not sufficiently described. Specific comments

are given below. English and Grammar (word order!) are incorrect in many places; examples are given below. I suggest to accept the paper with major revisions.

Major comments:

The paper suffers from a lack of actual data and a good instrumental background. The description of the "SR5000" on p7292 is not sufficient. Is there any literature reference that can be provided for the instrument? The only information given is that it is a "calibrated spectro-radiometer" in the range from 2.5 μm - 14 μm . Only later do we find out that it has 67 wavelengths. Does this mean that the spectral resolution is about 0.2 micron? What kind of spectro-radiometer is it? What is used as detector? Can the calibration be tied to any national or international standard source, and how is it done? Is the spectral calibration stable over the course of an experiment? Is the stability tracked during a field experiment? Is the noise level dependent on the temperature of the instrument, and is the temperature stabilized? (...)

At least one actual measurement should be shown of a spectrum and of a dark spectrum (if applicable).

Early on in the paper (p7284, l14), it is stated that a technique "similar to Rodgers (2000)" is used here. This obviously refers to optimal estimation techniques (or does it not?) - but the method used here has nothing to do with that, at least judging from the current manuscript. The covariance matrices used in the optimal estimation scheme, as well as state and measurement vectors should not be confused with the matrices shown in this paper.

I see two impediments for a global use of this technique: (1) The technique was only analyzed for warm clouds at a fixed altitude, but clouds in nature do not occur at fixed altitude. How can cloud top/base height be disentangled in a future retrieval? (2) As shown in this paper, atmospheric profiles have a huge impact on the differential spectra. Will it be feasible to run forward calculations for any profile at any given site? Will the retrievals still be unique, given (1) and (2), or do the altitude and atmospheric profile

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introduce too much ambiguity? The explanation given on p7301,15-11 is insufficient.

Many of the "thin" clouds in nature are actually Ci (some of which subvisible). How would the retrieval perform for ice clouds?

State in the abstract that the retrieval only works for optical thickness values up to 5. In fact, this paper would be a nice complementary paper to the techniques proposed by the papers by Marshak and Chiu (2008, 2009), as well as McBride et al. (2011). Those techniques are based on shortwave ground-based observations. They work only when clouds are thicker than a certain threshold optical thickness (around 3).

It should be stated in the paper that even though a sizable fraction of the global albedo may be due to small clouds, the thicker clouds do contribute considerably to cloud forcing, albedo and absorption. Since the technique presented here goes "blind" with respect to the effective radius above an optical thickness of 5, it is important to have complementary techniques (see comment above) that cover the higher optical thickness domain.

The paper title suggests the retrieval of a wide range of microphysical cloud properties, but the retrieval of effective radius is the only part that is described in some detail. The retrieval of liquid water content (or liquid water path), on the other hand, is not validated. There is one figure for the validation of the effective radius retrieval; a similar figure should be added for the LWC / LWP and/or optical thickness, or some other means of discussing this aspect of the retrieval should be included. On p7288,113 it is mentioned how to distinguish between different effective radii, but not how to distinguish between different optical thickness values. For energy budget applications, the optical thickness is even more important than the effective radius.

Although listed as a parameter in table 2, the impact of the thickness of the cloud layer on the spectra is not discussed in the paper. Add a discussion of the sensitivity.

On p7293,117, "inherent spectral features" are mentioned that are then analyzed by

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means of PCA. It remains unclear how PCA detects these features, and even what those are. Which time interval was used as a basis for the PCA? What data were analyzed: only dark spectra, or actual measurements? Also, the connection between PCA eigenvectors and SAM is unclear; the PCA are derived from the spectral variability of the data set as a whole whereas SAM constitute the spectral angle between two individual spectra. p7294,l9-11 do not seem justified, and this section needs to be improved.

Where do the error bars in Figure 23 come from? Also, some explanation about the retrieval of the liquid water content should be given.

Minor comments:

p7278,l7: "vast majority of remote sensing techniques are focused on thick clouds" – This is not true - lidars have been very successful in retrieving thin cloud properties up to optical thickness of 4.

p7284,l18: What is "standoff detection"?

p7294,l20-21: "The band. . . that its absence. . ." Unclear - is there an issue with word order?

p7294,l20: If Rodgers (2000) had truly been applied, the information content could have been determined directly, rather than gradually eliminating individual wavelengths.

p7298,l8: AERONET provides the optical thickness in the visible / NIR wavelength range. Why is that value used in the IR as well?? Surely the IR aerosol optical thickness is lower than that determined by AERONET.

p7298: In Figure 15, it is unclear what the SAM angles mean. Shown are SAM angles as a function of (cloud droplet?) effective radius, but isn't this figure supposed to illustrate and analyze the effect of aerosols, not clouds? Also, when it is mentioned that the "SAM look similar to that of water clouds", it is unclear what the readers should compare to. Are water-cloud-only (no aerosol) SAMs shown as well in some other figure?

If so, in which one?

The word, "nevertheless" is over-used. Sometimes, "however" is the better word. For example, on p7301,l7.

p7301,l21: The explanations given about the instrument do not need to be re-iterated here.

p7301,l23: What is a circular variable filter, and why is it only mentioned here and not in the paragraph about the instrument?

Technical comments:

p7280,l2: "one thing in common" – too colloquial

p7283,l28: "attenuate" → "attenuates"

p7284,l10: delete comma

p7284,l11: "some" → "a"

p7284,l12: "some" → "a"

p7285,l5: "It includes" → "It is based on"

p7285,l10: "either using" → "either by using"

p7291,l23: "in" → "at"

p7292,l7: "Under" → "For"

p7292,l21: "in the" → "at a"

p7294,l16: "in light the above" → "in light of the above"

p7295,l13: "induce bias" → "induce a bias"

p7295,l22: "water vapors do not scatter" → "water vapor does not scatter"

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p7295,l22: "down welling" → "downwelling"

p7295,l27: "Under" → "for"

p7296,l5: "stands on" → "is" (stands on doesn't make sense here)

p7296,l12: delete comma

p7296, lower part of the page has numerous issues with English (word order, use of "sounded", "clouds with LWC at most. . .", etc.)

p7297,l9: "Apart the" → "Apart from the"

p7297,l14: "retrieve" → "determine"

p7297,l16: "which are here" : fix word order

p7300,l1: "kind of haze" → "kinds of haze"

p7301,l9: "profile" → "profiles"

p7301,l10: "trustable" → "a trustworthy"

p7301, lower part of page: problems with English (e.g., "stands in the basis" →?, word order, appending a sentence after "namely")

p7302,l14: "droplets" → "droplet"

p7302,l22: "essential the" → "essential that the"

p7302,l22: delete "would"

p7303,l17: "whom" → "which"

p7303,l20: delete "naturally"

p7303,l21: delete "Nevertheless, and"

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 7277, 2011.

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