

Interactive comment on “Distinction between clouds and ice/snow covered surfaces in the identification of cloud-free observations using SCIAMACHY PMDs” by J. M. Krijger et al.

Anonymous Referee #1

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The paper is a technical description of how to distinguish between clouds and ice surfaces given the polarisation detectors (PMDs) of SCIAMACHY. The aim of this distinction is to identify cloudfree scenes for study of tropospheric trace gases with SCIAMACHY. The paper can be useful for people who want to perform this distinction using PMDs alone. Generally speaking, the paper should be made more scientific by improving the physical background, and by giving more quantitative information on the comparison results.

Specifically, I have the following major criticisms on the manuscript (points 1-6), which

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have to be addressed satisfactorily before the paper can be accepted for ACP (substantial revisions). In addition I have some more technical and/or detailed comments, points 7-25.

1. The PMDs are specially designed polarisation detectors. However, polarisation-correction of the PMD signals themselves is not performed in this paper. This is strange, and contradicts lines 98-103. The error which this missing polarisation-correction of the PMD signals is causing on the PMD cloud detection and ice detection has to be assessed.

Please note that especially at high latitudes where snow/ice surfaces occur, the solar zenith angle is large and consequently the degree of polarisation may be high, also in PMD2 and PMD3. There it is not true that the degree of polarisation $q=|Q/I|$ is less than 0.1, as stated on line 117, since q can be much larger.

2. The spectral difference at 1.6 micron between clouds and ice/snow surfaces is not explained in a physical sense. The reason of the difference is the difference in refractive index (imaginary part) between water and ice particles, and the difference in size of the particles. There are many publications on the 1.6 micron absorption features of water/ice, and already some publications aimed at using SCIAMACHY channel 6 data for cloud phase discrimination (Knap et al., JAS, 2002, Acarreta et al., Atmos.Res., 2004). The paper lacks a reference on the physical principle, and the use of SCIAMACHY near-IR spectra for distinction between water and ice. See also next comment.

3. The paper does not make a difference between types of clouds. There are water clouds and ice clouds (and mixed-phase clouds). Ice clouds have a similar spectral behaviour as ice/snow surfaces. Therefore, the distinction proposed in this paper between clouds and ice surfaces will probably not hold for ice clouds. This limitation has to be mentioned clearly.

4. The signals of the PMDs are not calibrated. Therefore, they do not have a physical meaning, and are only instrumental counts. The given criteria for thresholds are there-

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fore only instrumental values. The data processor version should be mentioned, since the counts may be different for different processor versions (due to corrections for dark current, stray light, etc.).

5. I have problems with the RGB colouring as used in Figs. 1 and 2, in Eq. (2) and in the footnote on p. 5: (a) There is no green in PMD3! The wavelength range of PMD3 is 610-690 nm according to Table 1. Green, however, is around 550 nm, where the chlorophyll spectrum has a peak. So it is not possible to get a green colour from PMD3. Perhaps, in the SPICl algorithm green is made as a pseudo-green colour from the PMD4 signal? Beyond 700 nm vegetation is highly reflective, so PMD4 has a high signal. (b) Figure 1 can be removed, since this colour coding is apparently not useful. Fig. 2 is a much realistic true colour figure. However, this figure was made with the RGB coding of the footnote on p. 5. Move therefore the footnote to the main text or to the figure caption. (3) There is confusion on the preferred RGB colour scheme according to this paper: Eq. (2) seems to be a third variation of RGB colouring, in addition to that of Fig. 1 and Fig. 2.

6. Fig. 12 shows that the saturation parameter S is not such a good quantity to separate clear from cloudy scenes. The branch on the right-hand-side contains a mixture of blue and red points (confidently clear and confidently cloudy points according to MODIS). The agreement between SPICl and MODIS is less good than claimed on line 316 of the paper. The actual (dis)agreement between the SPICl results and the MODIS results should be made more quantitative: give the percentage of successful and unsuccessful identifications by SPICl for clear and cloudy scenes.

Detailed comments:

7. l. 47: refer to the SCIAMACHY L1 ATBD (Slijkhuis et al.).

8. l. 57: there are two other cloud detection methods for SCIAMACHY: SACURA (Kokhanovsky et al.) and HICRU (Grzegorski et al.).

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9. It should be mentioned that cloud detection methods using the O2 A-band, like FRESCO and SACURA, are also detecting the pressure of the clouds or the surface. The pressure can be used to discriminate white clouds from a white surface.

10. I. 80: How does MODIS separate clouds from snow/ice surfaces? This has to be mentioned.

11. Eq. (1) is unclear: why is the main spectral channel diode i included? R_{PMD} represents only the PMD response due to incident Earth radiance I and polarisation q and u , which both depend on wavelength of course. Please remove the index i and make wavelength a continuous variable for all parameters.

12. The symbol R in Eq. (1) suggests a reflectance, whereas it is a raw instrument signal. This signal varies with the incident sunlight variation. Please change for another symbol to avoid confusion.

13. On I. 123 it is said that each PMD signal is corrected for the viewing zenith angle (VZA) and solar zenith angle. Please specify how this is done.

Why is a correction for the viewing zenith angle needed? I hope you do not mean a factor $1/\cos(VZA)$, because that would be erroneous.

14. Line 149 ff: optically thick clouds are white, but optically thin clouds are less white, may show the spectrum of the Rayleigh atmosphere and underlying surface.

15. What is the used MODIS image resolution? There are different values mentioned on lines 171 and 180.

16. Table 2 is not needed. The three numbers can more effectively be given in the text below Eq. 2.

17. Eq. (4) can be removed. The single threshold value can be mentioned in the text. Furthermore, it is repeated in the recipe of the method given in Eq. (6).

18. Please change "then" into "than" in comparisons (line 117, and other places).

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19. Eq. (3) should be clarified: to which set does the min and max refer? One state, one orbit, or one year of data?

20. Fig. 4: For how many SCIA states is this comparison between SCIA and MODIS performed? What was the underlying surface? The threshold for S, 0.35, is apparently based on this limited set of data. How reliable is its application to global data from SCIAMACHY, where different surfaces and cloudy scenes may occur?

21. The spectra of Fig. 6 apparently are not including ice clouds, but only water clouds. Ice clouds might also be dark in PMD5. This should be mentioned in the description.

22. Figs. 10 and 11 have a too complicated colour coding. The legend is not clear. In addition, the legend is hiding part of the relevant parts of the image.

23. The term South Pole (SP) used in this paper (e.g. on line 245 ff, and in the caption of Fig. 10) is not correct. Meant is Antarctica. The SP is at exactly 90 degrees South, which location is even missing in Fig. 10.

24. Eq. (5) can be removed; the thresholds can be given in the text. Eq. (6) suffices for the SPICl thresholds. Suggestion: a flow diagram, instead of the list of (in)equalities of Eq. (6), would be easier to understand for the reader.

25. line 308 ff: "quadrant" > "part" (since a quadrant is exact 1/4-th).

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