Atmos. Chem. Phys. Discuss., 2, S1162–S1168, 2002
www.atmos-chem-phys.org/acpd/2/S1162/

Atmospheric Chemistry and Physics Discussions

ACPD

2, S1162–S1168, 2002

Interactive Comment

Interactive comment on "Retrieval methods of effective cloud cover for the GOME instrument: an intercomparison" *by* O. N. E. Tuinder et al.

O. N. E. Tuinder et al.

Received and published: 14 December 2003

This is the reply to the two anonymous referees and Mr Loyola on the interactive comments on
"Retrieval methods of effective cloud cover from (/for) the GOME instrument: an intercomparison." by Tuinder et al.

We thank both anonymous referees and Mr. Loyola for their effort spotting typographical mistakes and for their suggestions for additions. These suggestions were implemented as much as possible. Also, some sections of the text were changed in order to clear up some parts where we omitted information or where a more extended argumentation was needed.

Below is a list of itemised answers to a number of questions from the referees where the authors thought a more elaborate answer was needed, which is not covered in the paper itself.

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Interactive Discussion

Discussion Paper

- Referee #1 suggest a title change to '... cloud cover from ...'.

  We agree that this change is appropriate, and changed the title accordingly.

- Referee #2 asked for scatter plots of cloud retrievals of PCRA, OCRA and FRESCO.

  Scatter plots of individual PMD retrievals and averaged values over a GOME pixel were added to the paper in a new section.

- Both referees ask why (only) August ('97, '98, '99) was taken as a dataset.

  This was a relatively arbitrary choice, based on possible overlap with other research projects that one of the authors had at the time. We agree that only using August is limited, but to compose a good minimum thresholds database or cloud-free database for a complete year means that all level-1 data for that year needs to be extracted, and processed. This is a task for which the authors have no resources.

- Referee #1 asks why the backscan GOME pixels were not used.

  The backscan pixels were not studied because the very wide swath of this type of pixel ($960 \times 40\ km^2$) means that the characteristics of the surface and the clouds in the field of view are likely to vary so much that a comparison of the algorithms is complicated.

- Referee #2 asks why the cloud top height of RCFA was not used to compare with FRESCO.

  The main reason for this is that, although we tried, the code for the original PCRA and RCFA algorithm did not run on our computer platform. We can get the source compiled, but it crashed during a run.

- Referee 1 asks about what happens above snow and ice surfaces.

  The current retrievals all have problems distinguishing between high reflecting surfaces and cloud. Most use a flag to signal the uncertainty or give an error value. A new paragraph was added to the paper to discuss this.

ACPD

2, S1162–S1168, 2002

Interactive Comment

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Interactive Discussion

Discussion Paper

- Referee 2 says that GOME results depend on the SZA and therefore change with latitude and that data products must be expected to differ for different places in the world.

  True, but the argument that is made here is that the synoptical observer does no uniform measurements, while other known factors such as SZA for satellite results or spherical corrections at high SZA in RT models can be taken into account if needed.

- Referee 1 and 2 ask what the explanation is to the elevated cloud fraction over the desert in the track analysis and why this may not affect the other methods.

  We speculate that the higher cloud fractions may come from sand albedo or when aerosols that are present at the time of the overpass while the minimum albedo database achieved lower values in a rather large gridbox over time. The extra reflection and scattering leads to a higher signal and is interpreted as a cloud. The other retrieval methods benefit from a smaller albedo grid size wherein the minimum reflection changes with respect to location are smaller.

- In his general comments, Mr. Loyola stated that the original OCRA algorithm should be used and not our own implementation.

  The reasons for using our own implementation are twofold.

  First, at the time when we started this research, both the OCRA and PCRA algorithm were only available as publications in proceedings and as a draft report without source code. Therefore, we implemented PCRA and OCRA as it was described in the literature and did our comparisons with that. When the source code was released, we could not get the official version to work due to binary incompatibility of the database file with our platform. The same holds for the official version of PCRA, which also does not run on our platform for unknown reasons.

  Second, our main criticism on OCRA is not based on statistics (which are dependent on the implementation), but more on the methodology due to the effects we see in the cloud free database and when we perform the scaling and offset when we execute the method as described in the literature.

ACPD

2, S1162–S1168, 2002

Interactive Comment

Until recently, we had not re-attempted to compile and run the original OCRA source code, but now we got it working and have included results of this implementation in this revised version of the paper.

- Mr. Loyola states that the scaling and offset factors should be determined using only GOME PMD data, and that the factors for the official algorithm were determined using selected GOME orbits via histogram analysis. He further says that external data, such as ICFA, can be used as an alternative but is not needed.

  The authors feel that the selection of the offset factors can easily be done via histogram analysis because there is a rather sharp cutoff in the frequency diagram when the calculated cloud fraction of PMD pixels that are supposed to be cloud free are analysed. The key factor is to determine whether the PMD pixels are really cloud free. From a histogram analysis of PMD data alone this is not apparent, as one will always get a distribution with a certain width. An external data source can be used to point out those pixels that are more likely to be cloud free, and the offset factor can be determined with less uncertainty.

  The determination of the scaling factors is more difficult, as a frequency diagram of the PMD cloud fraction will show a 'bell shaped' curve. The description of the OCRA algorithm (ref ESA_CRAG_2000, Loyola_1998) does not state the criterium that was used for the selection/optimisation of the scaling factors that would result in a cloud fraction of 1. Even more than for the offset factors, the key is to select which PMD pixels represent a fully clouded pixel in order to optimise the scaling factors.

  With respect to the use of ICFA data, the authors agree with Mr. Loyola that ICFA should be used with caution due to its deficiencies. Because we only used ICFA to select multiple cloud free and fully clouded pixels (as end-points of the scale) to optimise the selection of the offset and scaling factors, this will have no great effect in comparison with a free PMD search.

  The comment in the previous version of the paper that OCRA is not an independent method is retracted.

ACPD
2, S1162–S1168, 2002

Interactive Comment

- Referee #2 says that the use of ICFA for the selection of the OCRA offset and scaling factors has implications for the OCRA results and that this should be stated. Following the discussion above, wherein the selection methods of the offset and scaling factors is discussed, we feel that the use of ICFA does not have such severe implications in this case.

- Both Referees ask why we determined our own OCRA offset and scaling factors, instead of using the default.

  In an answer to Mr. Loyola above we explained that when we did the study no source code was available and we had to code our own algorithms. This also meant that we needed to determine our own offset and scaling factors. The factors provided with the official source code on cdrom with the ESA 'CRAG' report (2000), seem closely connected to this particular implementation of the OCRA algorithm. In the official code, the default offset factors for PMD1–PMD3 are (1.0, 3.0, 5.0) and the scaling factors are (0.03, 0.02, 0.02) respectively.

  In the extracted (ASCII) GOME level-1 data, we find that the values of each PMD channel generally ranges between 0.05 – 0.3.

  Following the first part of the standard description of the OCRA algorithm, we fill in the numbers above.

$$f_i(\lambda) = max\Big(0,\ S(\lambda)[(\varrho_i(x,y,\lambda) - \varrho_{CF}(x,y,\lambda))^2\ -\ O(\lambda)]\Big) \tag{1}$$

$$f_i(\lambda) = max\Big(0,\ 0.03 * [(0.3 - 0.05)^2 -\ 1.0]\Big) \tag{2}$$

  The calculation learns that the result of the OCRA PMD cloud fraction is a small, but negative number (-0.028 before a SQRT of the sum is taken, or an imaginary '-0.17' afterwards) and that the cloud fraction contribution of this subpixel will be zero due to the max function in equation (2). While we used the maximum reflectivity representative for a PMD channel, a resulting cloud fraction of zero was not what we expected. Therefore,

ACPD

2, S1162–S1168, 2002

Interactive Comment

we concluded that our implementation differed internally, and that we needed to select our own offset and scaling factors to test the proposed methodology. The OCRA algorithm also specifically allows for a set of user-defined factors.

- Mr. Loyola says, with regards to page 637 of the original manuscript, that "The OCRA cloud-free is indeed the minimum in the three dimensional space RGB, see (19). This three dimensional minimum will not correspond to the lowest reflectance available if each R, G and B components are ranked separately".

  While we agree on the second part of his comment (that the cloud-free as obtained by OCRA does not produce the lowest reflectance if each of the RGB components are ranked separately, we disagree with him on the first part. We assert that OCRA loses valuable information on signal strength in rg-space, which means that the selection procedure cannot positively determine the lowest reflection in RGB space. Let us illustrate this with an example. A cloud is assumed to scatter light in all three PMD wavelength components more or less equally. Therefore, a point that has (R, G, B) = (1, 1, 1), is represented in rg-space as (1/3, 1/3). Now we take a very dark surface, with (R, G, B) = (0.001, 0.001, 0.001). This dark and almost black point will end up in the white point in rg-space and is therefore supposed to be a cloud and discarded as the minimum reflectance. The signal strength (intensity) is lost in the process of normalisation.

- Also with regards to page 637, Mr. Loyola says, that the PCRA minimum reflectance is more smooth because it is a synthetic product and OCRA is based on real PMD measurements.

  The section referred to has been rewritten to reflect this, however, we still see this as a weakness in the OCRA algorithm when large areas of Earths surface show a structure that is not likely to be real (for instance, large areas of ocean at the same latitude, like shown in figure 4 in the paper).

- With regards to page 646 (lines 12-17), Mr. Loyola says that the argumentation followed in this paper is not valid for the original OCRA algorithm and that the conclusions should be revalidated using the original algorithm.

The authors have retracted the comment on the dependency of OCRA on other datasets, but still support the conclusion that the unnatural patchy behaviour of the cloud-free database and the heavy dependency of OCRA on the offset and scaling factors are weaknesses of the method and this is stated as an opinion.

- With regards to Fig. 4., The color figure is an image where the three PMD components of the cloud-free database of OCRA and minimum thresholds of PCRA of a part of the Pacific Ocean are depicted in RGB color with equal scaling with respect to signal strength.

ACPD

2, S1162–S1168, 2002

Interactive Comment