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Atmospheric Measurement Techniques Discussions

Interactive comment on "Seven years of global retrieval of cloud properties using space-borne data of GOME-1" *by* L. Lelli et al.

Anonymous Referee #2

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General comment

The topic of retrieval of global cloud properties from satellite observations is very relevant to climate studies. Homogeneous and accurate long time series of clouds are needed to detect possible trends and can be used as observational constraints of climate models. Therefore, the topic of this paper is relevant to AMT. However, the paper has serious shortcomings regarding missing references and comparisons to other relevant research and the questionable values of the reported global cloud results. Therefore, it cannot be published in its current form. Below specific comments are given.

Specific comments

The main shortcomings are:

(1) Results section: no reference is made to other published results from important cloud remote sensing satellite projects and instruments, like ISCCP, MODIS, AVHRR, HIRS, A-train etc.. The GOME data should be compared to other relevant data sources on clouds.

(2) The reported global mean cloud top height of 7 km seems much too high, given the fact that thin high cirrus clouds cannot be detected in the visible with GOME using the O2 A-band.

(3) The lack of low clouds, below about 2 km, in the presented GOME data set indicates a serious algorithm problem. The missing low clouds are clear from Figure 11 and especially from Figure 13. The ratio of low, middle, and high clouds shown in Fig. 13 is completely different from what is currently known from the literature. This has to be explained, especially because of the limited sensitivity of GOME to high clouds (for which thermal IR sensors are needed) and its strong sensitivity to low clouds which are very reflective in the visible and near-IR, which is the spectral range used by the algorithm. If low clouds are missing in the algorithm, the global mean results do not make sense.

(4) In order to retrieve CTH at wavelengths where multiple scattering is important like the O2 A-band, the geometric thickness L of the cloud should be either retrieved or assumed. In section 2, page 4997, line 4, L is mentioned, and there it is said that it is retrieved. However, in the paper no error analysis of the retrieval of L is given and no results of L are shown or mentioned. Does the retrieved value of L cause the deviating (too high) CTH?

(5) The retrieval model discussed in sect. 2, page 4995, is only valid for water clouds, since the assumed asymmetry parameter g is 0.859 (line 22) whereas ice clouds have a much smaller g. What is the quality of the SNGome retrieval for ice clouds? How does this affect the global mean of cloud properties reported in the paper?

(6) Looking at the zonal mean results of clouds given in Table 7, it appears that if this would be true, the Earth's albedo would be much higher than currently known! By multiplying a cloud fraction CF of about 0.8 with a cloud albedo CA of about 0.6 a value of 0.48 is obtained for the global mean albedo of the Earth caused by clouds. After adding a contribution from the clear sky albedo, this would mean a global mean albedo of about 0.5, which is much higher than the currently accepted value of 0.3 (e.g. Trenberth et al., BAMS, Volume 90, 311 – 323, 2008). This is a fundamental problem with the zonal mean cloud results of this paper.

(7) A possible explanation of the above mentioned deviating results could be that the retrievals of the paper do not belong to all clouds, but only to the thickest clouds, for which the asymptotic relations used in the SNGome algorithm hold. But this rises the question what the zonal and global mean values refer to.

Other specific comments

Title and throughout the paper: the name GOME-1 does not officially exist: it is GOME on ERS-2.

Abstract, line 7: mention that the results of the paper only hold for optically thick clouds, since asymptotic relations are being used.

Abstract line 14 and throughout paper: the average cloud top height of 7 km is very high. This seems to be unrealistic. There is no other basis for this high CTH value.

Introduction: references are too scarce. Mention that clouds are usually better studied with imagers (with spatial resolutions of the order of 1 km) than the coarse resolution spectrometer GOME. Mention relevant studies of these imagers. Give arguments why a study of clouds with GOME is nonetheless relevant.

Section 2, p.4993: Here also reference is needed to the FRESCO cloud algorithm for GOME, as published by Koelemeijer et al. (JGR, 2001, 2002), Wang et al. (ACP, 2008) and available as GOME cloud product via www.temis.nl.

Section 2, p. 4994: line 3: this depends on the height of the cloud line 6: single scattering albedo: do you mean plane albedo? Line 10: middle of the cloud: refer to the earlier papers on this topic, e.g. Sneep et al., JGR, 2008. line 20: mention the GOME spatial resolution

p. 4996: line 5: what does the algorithm do with clouds which have optical thickness $<$ 5?

p. 4997: line 4: which equation yields geometric thickness L in the retrieval algorithm?

p. 4997, line 23: where is the aerosol information in the cloud retrieval coming from?

p. 4999, line 3: please discuss here the results shown in figure 3.

p. 5001: line 17: please show the results of COT in a figure or discuss them more quantitatively in the text. The COT is very relevant to the spherical albedo given in Table 7.

p. 5002, line 2ff: four orbits of GOME data is statistically insufficient to give a quantitative quality assessment. Furthermore, the smaller pixel size of these four orbits is not representative of the pixel size of the global GOME data set that is the topic of this paper.

p. 5002, line 25: Figure 6 shows large differences in CTH of several km between the two GOME cloud data sets; this should be discussed.

p. 5003, line 15ff: Comparison to earlier results is needed. Please give here appropriate references to cloud results of other groups, and compare your results. Zonal and global mean cloud results from GOME have been published before by Loyola et al. (2010), International Journal of Remote Sensing, 31:16, 4295-4318.

p. 5003, line 27: please use the term "marine stratocumulus clouds", which is the most reflective and abundant low cloud type, typically at an altitude of 1-2 km.

p. 5004, lines 10-12: it is a serious algorithm problem if it cannot detect the low clouds which are the most reflective. See earlier comment (3).

p. 5006: the study seems to show that the global mean cloud height is that of high clouds, above 6.5 km. This conclusion should be verified by a lot of independent satellite and groundbased information, otherwise it is not acceptable.

p. 5007, lines 21-24: this CTH comparison of GOME with SCIAMACHY is not an independent one, since the same (or a very similar) algorithm was used. The global mean CTH of 7 km has to be confirmed by independent information.

Specific comments to tables and figures:

Table 1: ERS-2 with GOME on board was switched off on 4 July 2011.

Table 3: mention the ARM project.

Table 4 and 5: give the number of data points used in the comparison; this indicates the significance of the comparison.

Table 4: define deep and shallow clouds; define the bias.

Table 5: define the bias.

Figure 1: use a smaller CTH error range to see a larger range of colours and more structure in the plot. To which geometry do these calculations pertain?

Figure 2: this figure is dominated by strange algorithmic features; please remove this plot.

Figure 3: is very unclear.

Figures 4 and 5: mention the number of cases; define deep and shallow.

Figure 6: Please show all three CTH products: SNGome, ROCINN and ATSR, so that the reader can compare the three. Please also show the cloud fraction CF itself, and not only the difference ATSR-OCRA.

Figure 6: It would be useful to show the correlation between the three CTH products for all data points of the four orbits.

Figure 7: indicate the months in each subplot.

Figure 11: indicate in the caption: North = 0 - 70 deg N, South = 0 – 70 deg S.

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 4991, 2011.