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Atmospheric Measurement Techniques Discussions

Interactive comment on "A simple and versatile cloud-screening method for MAX-DOAS retrievals" *by* C. Gielen et al.

Anonymous Referee #2

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The study of "A simple and versatile cloud-screening method for MAX-DOAS retrievals" by C. Gielen et al. presents an important cloud screening method to be applied to large data set of passive remote DOAS instruments, in particular for zenith sky view. The method applied here follows up the study by Wagner et al (2014) about the effect of clouds on several MAX-DOAS observations such as radiances, colour index (CI), ring effect (Raman Scattering Probability, RSP) and O4 absorption (based on air mass factors, AMF). In this work the approach is simplified by using only CI, O4 dSCD, the zenith sky view, and is based in a general simulation of the CI. The method applied here has great potential, especially for long term zenith sky measurements, however the application of this method to off axis MAX-DOAS measurements might need more analysis regarding the primary objective of using several elevation angles with MAX-

DOAS (as stated in the title of this work). I recommend publication after addressing the main points below:

One of the main observations is in the application of this method on MAX-DOAS measurements which use multiple elevation angles. This work focuses only in the effect of the CI, and O4 dSCDs using the 90 elevation angle, however the line of sight of 90deg can be completely different than the line of sight of lower elevation angles. The justification of using only 90deg for this work is that simulations with radiative transfer model show a higher contrast in the CI using 90deg than lower elevation angles (Fig 2). In general MAX-DOAS measurements spend more time in the off axis scan measurements, or even in only one low elevation angle to obtain boundary layer trace gas mixing ratios. If the method proposed here is applied to MAX-DOAS I would think that at the end of the screening method it will remain less/more points if using only the 90EA in order to filter all elevation angles. This in fact is pointed out in section 6 where the cloud screening is applied to aerosol model retrievals and broken clouds are removed. The authors should address the application of this method to MAX-DOAS inversion by studying the effect of broken clouds and aerosol in-homogeneity along the different EAs, otherwise they should state that this method can be applied to zenith sky DOAS. Have you thought using the ratio or and indicator of two different EAs (for example 2 and 90deg). Also, Wagner et al (2013) studies the effect of the Ring effect (Raman scattering) but here it is not mentioned at all. I suggest an analysis in the advantages of using only CI and not the Raman Scattering.

The authors describe the impact on aerosol retrievals by comparing the AOD retrieved with MAX-DOAS and AERONET. This comparison is important to check compatibility between the method applied here and the cloud screened filtering applied in the AERONET data L1.5. However the analysis in this work is focused in the AOD comparison. This comparison might not highlight the importance of the cloud screening method due to two main reasons (1) the air mass probed by the two instruments can be quite different, MAX-DOAS has a unique directionality, on the other hand the AERONET sun

photometer tracks the sun; and (2) AERONET L1.5 is a cloud filtered product. In section 6.2 p5898 there is a basic description about the AOD products from AERONET, Brewer which reads “we do find that data for which no measurements are available are generally flagged by our method as cloudy, showing the coherence between our cloud screening and that of the other instruments”. It would be important if more detail is given about this comparison. I would suggest a thorough and quantitative comparison of the times where AERONET L1.5 or (Brewer) filtered data with their own cloud screening and can potentially coincide with the method applied here.

The method applied here is based in the comparison of the CI using a based RTM simulation and measurements under different cloud conditions. In section 3 the simulation of the CI is introduced, however I did not find in this section or in figure 2 the wavelength range where the simulations were made. My point of this observation is regarding a comparison with measurements since most of the time filters are used to avoid stray light. Could you please expand the description of the three instruments, especially whether filters were used to eliminate stray light to the spectrometer, and what kind of effect do you expect in the CI if filters were used? If not filters were used it would be valuable for the application of this method to elaborate in the effect of filters which are very common in the passive remote sensing observations.

Minor observations:

Line 11: Here, in the introduction, is mentioned “we focus on 90 elevation observations since simulations show these are the most sensitive to the sky conditions”. Please indicate or introduce a reference pointing this out.

Sec 2.2, p5888 Change “Rayleigh and Mie scattering” for “scattering due to molecules and particles”

The viewing angles (azimuth angles) are missing in the description of the Jungfraujoch and Brussels instruments.

Please elaborate more in the DOAS analysis of O4. Do the UV and visible analysis carry less/more/the same information for the cloud screening approach described here?. The UV spectra range might be sensitive to air mass closer to the instrument, while the distance range in the visible may be larger. Also, it has been noted a “correction factor” in Clemer et al of 0.8, is this correction factor applied here?. Please elaborate more in the use of this correction and for which elevation angles is important and how this factor could potentially affect the CI.

This method is applied using only zenith sky spectra, however is restricted only to SZA < 85. . . what do the authors recommend for SZA > 85. This might be important for the zenith sky DOAS where stratospheric trace gases are aimed, particularly for SZA > 85

it is noted here that the main sensitivity in the simulations of CI was using a cloud base height at 1km, but is not clear what was the actual altitude of the cloud. Please expand more in the sensitivity studies of the CI, especially in the type of clouds, altitude (distance from the ground and vertical extent - cloud thickness), and for different elevation angles.

The description of figure 1 on the main text refers to figures 1a-d, however the labels (a,b,c, and d) are missing in the actual figures. The color chosen for the Elev=2,8, and 90 are difficult of distinguish, please change it accordingly.

The AERONET component is very important along this manuscript, for instance, in fig.1 the aerosol load is essential in order to makes sense of the CI and O4 dSCDs. For the fractional day 35 in figure 1 the AOD increases in the early morning, however there is not data after $\sim$35.25. The AERONET data used in this work is level 1.5, which is cloud screened data, so presumably when there is not AOD data there are clouds present, could you please expand a description when there is not AOD in terms of O4 dSCDs and CI for this figure?. Also, the fractional day in fig 1 is confusing. The measurements started at 35.0, is this midnight?.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 5883, 2014.