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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Comparison of Box-Air-Mass-Factors and Radiances for Multiple-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) Geometries calculated from different UV/visible Radiative Transfer Models" *by* T. Wagner et al.

T. Wagner et al.

Received and published: 7 January 2007

Reply to ref #1:

We want to thank this referee for the positive assessment of our manuscript and the helpful comments. We almost completely followed them (and explain the reasons in cases we did not follow them completely), as outlined in detail below. Before we respond to the specific comments, we briefly describe some additional changes, which were recommended by two other referees and/or the co-authors of our study.

A) Figures

Of course it is difficult to present this huge amount of information within a limited space. We tried to solve this dilemma by increasing the labels of almost all figures. In some cases, it will also be possible to increase the size of the figures (depends also on the final layout).

B) Better separation of main foci

It was stated by the referee that the two main foci (RTM comparison and investigation of MAXDOAS sensitivities) should be better separated. We agree and modified the abstract, introduction and conclusions accordingly. In the abstract and conclusion we added one sentence which points out the two main foci of the paper ('Besides the assessment of the agreement between the different models, a second focus of the comparison was the systematic investigation of the sensitivity of the MAX-DOAS technique under various viewing geometries and aerosol conditions.') In the introduction we rearranged the text to better separate both foci. In particular, we introduced to sub-sections 1.1 (Modelled quantities used for the comparison exercise) and 1.2 (MAX-DOAS observations). To make the structure of the paper more clear we added the section numbers at the end of section 1 and we added some more explanatory text at the beginning of section 3.

C) Statement on refraction

In the original version of the manuscript, only one sentence at the end of section 4.3 gave some information on the importance of refraction. We now added statements on the influence of refraction at the end of section 3.1: 'It should be noted that in contrast to the observation of zenith scattered light at large solar zenith angle, the influence of atmospheric refraction on MAX-DOAS observations is typically small. Even in the case of very long lines of sight (e.g. for 577nm, elevation angle of 1°, no aerosol, see section 4.3), the effect is at maximum a few percent. For typical atmospheric situations and measurement geometries it is negligible. Thus for this comparison exercise, the

ACPD

6, S5998–S6003, 2007

treatment of refraction in the individual models was not specified.'

Also in the conclusions we added more information (at the end of the sentence: '..the correct treatment of the Earth's sphericity becomes indispensable') we added: '(while the effect of atmospheric refraction is typically negligible)'

D) additional minor corrections

Page 2, equation 2:

In many cases, the normalised radiance is defined with Pi in the numerator. In our RTM comparison, the normalised radiance was simply formed by the ratio of the modelled radiance and the solar irradiance. Thus we changed equation 2 accordingly.

Page 3, line 14: 'Ěwhich is a fundamental prerequisite for their correct interpretation.' changed into 'Ěwhich is a fundamental prerequisite for the correct interpretation of these observations.'

Page 5, line 10: The sentence 'For these cases, they can also be approximated by the intensity weighted average geometrical path length extension with respect to the vertical thickness of the selected layer.' Is replaced by 'For these cases, they can also be approximated by the intensity weighted geometrical path length extension with respect to the vertical thickness of the selected layer, averaged over all contributing light paths.'

Page 6, point A): The sentence 'A) The comparison and quantification of the differences of current RTMs from different research groups.' is replaced by 'A) The comparison of current RTMs from different research groups and quantification of the differences.'

Page 18, line 11: at the end of the sentence: 'Both factors cause a monotonous increase of the normalised radiance with increasing elevation angle over the whole range of elevation angles.' The following text is added: '(it should be noted that this dependence can be different for relative azimuth angles other than zero)'

ACPD
6, S5998–S6003, 2007

EGU

References: We removed the reference Rozanov, A., V. Rozanov, and J. P. Burrows, Software package SCIATRAN 2 - New developments in the radiative transfer modeling and the retrieval technique, paper presented at COSPAR 2006, to appear in ASR, 2007. because the paper is currently restructured and the date of appearance is uncertain at the moment.

Technical correction: Since end of 2006, I am also at MPI for Chemistry in Mainz, Germany. I added this affiliation to the list of affiliations.

Ref. #1

Summary The paper reports on the results of a thorough comparison of radiative transfer modelling of sunlight in the atmosphere in the UV/Visible spectral range developed by 8 international institutes involved in ground-based, balloon, aircraft and satellite remote sensing observations of atmospheric composition. A broad variety of models is compared using either Discrete ordinate or Monte-Carlo techniques, in plane-parallel, spherical or mixed geometries, including or not atmospheric refraction. The exercise particularly oriented towards the interpretation of MAX-DOAS ground-based observations at elevation varying from 1_ to 90_ and azimuth from 0-180_, includes also sensitivity studies of ground albedo and aerosol loading on altitude weighting functions (Box-Air-Mass Factors). Overall, after correction of a number of errors in the simulations easily identified in the first comparisons, convergence within 5% between calculated Box-AMF and radiances was reached, providing the calculations are made in spherical geometry, concluded to be mandatory at observing elevation below 10_. On the application side, all simulations agree to confirm the extreme sensitivity of low elevation MAX-DOAS observations to aerosol loading and surface albedo.

General Comments The model comparison exercise reported in the paper is the result of a large and well-organised effort of a broad group of scientists involved in atmospheric observations by the UV-Vis technique. The paper fully fells within the area of interest of ACP and is very informative including a number of details of interest for ra-

ACPD
6, S5998–S6003, 2007

EGU

diative transfer modellers as well as for the general ground-based and space UV-Vis community. It is carefully written and almost acceptable for publication but the abstract, introduction and conclusion, which would require some reorganisation. Indeed, the paper address two different objectives, i.e. the evaluation of radiative transfer models and a sensitivity study of MAX-DOAS to aerosols, albedo etc, which should be better separated in the description of objectives as well as in the conclusions.

Author reply: We agree with the referee and modified the abstract, introduction and conclusions accordingly. In the abstract and conclusion we added one sentence which points out the two main foci of the paper : 'Besides the assessment of the agreement between the different models, a second focus of the comparison was the systematic investigation of the sensitivity of the MAX-DOAS technique under various viewing geometries and aerosol conditions.' In the introduction we rearranged the text to better separate both foci. In particular, we introduced two sub-sections 1.1 (Modelled quantities used for the comparison exercise) and 1.2 (MAX-DOAS observations).

Specific comments

1. Some models are including refraction. Others not. But nothing is said about the results of the comparison in this aspect.

Author reply: Many thanks for this hint. Because it turned out that refraction is not important for (almost all) MAX-DOAS observations, we forgot to mention the effect of refraction in our manuscript (except one sentence at the end of section 4.3). We now added statements on the influence of refraction at the end of section 3.1 and in the conclusions. New sentence in section 3.1: 'It should be noted that in contrast to the observation of zenith scattered light at large solar zenith angle, the influence of atmospheric refraction on MAX-DOAS observations is typically small. Even in the case of very long lines of sight (e.g. for 577nm, elevation angle of 1°, no aerosol, see section 4.3), the effect is at maximum a few percent. For typical atmospheric situations and measurement geometries it is negligible. Thus for this comparison exercise, the

ACPD
6, S5998–S6003, 2007

treatment of refraction in the individual models was not prescribed.'

New text in the conclusions (at the end of the sentence: '..the correct treatment of the Earth's sphericity becomes indispensable'): '(while the effect of atmospheric refraction is typically negligible)'

2. Is it really needed to provide a full list of publications at each step: 5 ref of satellite observations p 9826, 13 ref on Max-DOAS p 9827, another 8 ref on the same page, then Rozanov 2005, 2004-2006, 2007 p 9836 and again Rozanov 2000, 2001, 2005 a few lines later, etcEˇ Could be easily simplified by quoting the most recent + reference herein.

Author reply: We tried to minimise the number of references. At the introduction of the MAXDOAS technique we still keep all references, because we see the problem that the oldest references are typically important basic publications on the new technique, and the most recent publications can not already cited using 'and references therein'). Thus the reduction of references comes from the fact that we removed references on specific points and we reduced duplications. On several parts of the text we now refer to '..the references in the publication list given in (new) section 1.2').

3. The figures are fine and informative but labels are very small and difficult to read. I would recommend adopting the size of captions.

Author reply: Of course it is difficult to present this huge amount of information within a limited space. We tried to solve this dilemma by increasing the labels of almost all figures. In some cases, it will also be possible to increase the size of the figures (depends also on the final layout).

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 9823, 2006.

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6, S5998–S6003, 2007