

## ***Interactive comment on “SO<sub>2</sub> Retrieval from SCIAMACHY using the Weighting Function DOAS (WFDOAS) Technique: comparison with Standard DOAS retrieval” by C. Lee et al.***

**C. Lee et al.**

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Specific comments:

Page 10820: "It is speculated that this is related to interference from Ring but no clear..." has been replaced with "It is speculated that this is related to interference with Ring effect, the 'filling-in' of solar Fraunhofer lines in the scattered light, but no clear..." in the revised manuscript. A sentence "A reference spectrum to account for the Ring effect, the 'filling-in' of solar Fraunhofer lines in the scattered light, was calculated online" in page 10824 has been changed to "A reference spectrum to account for the Ring effect was calculated online..."

Page 10821: "Higher particle fluxes in this region result in random isolated spikes in

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SO<sub>2</sub>." has been added after "The Southern Atlantic Anomaly has "reaching the African coast.".

Page 10826, line 11-14: "while they are decreasing ... in the SDOAS retrievals" has changed to "while they are decreasing ... in the SDOAS retrievals (see Figure 3 (a))" in the revised manuscript.

Page 10826, line 14-15: the statement of "the O<sub>3</sub> column with ORSC is slightly lower" is to show that the O<sub>3</sub> amounts from fitting change with a Ring spectrum.

Regarding Figure 2:

A right axis has been added in the Figure 2 and 3.

BrO is included in the fit. So, it would be better to keep the BrO in Figure 2 for readers to see results of two fittings even though BrO is not mentioned in the text or caption.

The size of symbols in the key depends on their size in the graph. So, the description of color coding was also added in the caption.

Regarding Figure 3:

The size of symbols in the key depends on their size in the graph. So, the description of color coding has also been added in the caption.

The annotation along the axes has changed to be in a bigger font.

BrO is included in the fit to reduce the fitting residual in WFDOAS. The fit including BrO leads to smaller residual, but does not affect on SO<sub>2</sub> slant columns. Also, the number of polynomial does not have an affect on SO<sub>2</sub> slant column, but the polynomial of 3rd order lead to a little less residual in WFDOAS fit: The sentences in line 7-12 has changed to "The polynomial degrees and BrO do not have affect on SO<sub>2</sub> slant columns in the WFDOAS retrieval, not contributing the differences between SDOAS and WFDOAS retrievals. However, both the third order polynomial and BrO in the fit lead to less fit residual in the WFDOAS retrieval.".

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Sometimes Reference Sector Method (RSM) leads unrealistic high values over high latitudes ( $> 50^\circ$  latitude) in winter (at higher solar zenith angles), as mentioned in sections of Introduction and Conclusions. These high values are also seen in the SDOAS+RSM panel of Figure 4. It assumes that the reference sector over Pacific is SO<sub>2</sub> free, but the amount of SO<sub>2</sub> over the reference sector could be not zero.

Other Issues

page 10818

Line 7: "to solve" has replaced with "to figure out these problems and improve the retrieval" in the revised manuscript.

Line10: Both of "Chartography" and "Cartography" are used in English, and "SCIA-MACHY" is the acronym of "Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY".

Line 13: The authors think that WFDOS with ORSC can solve the spectral interference problems

Line 18: "aerosol" has been replaced with "aerosols".

Line 22: "The" before SO<sub>2</sub> has been removed.

page 10819

Line 3: The brackets has been removed

Line10: "the" before "climate" has been removed.

Line 7/8: "... the estimates ... not easy to determine ..." has changed as suggested by the referee.

Line 12: A new paragraph after "difficulties" gets started, and "The" before SO<sub>2</sub> has been removed.

Line 13/14: The sentence has changed to "... 1983), and later using other satellite  
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instruments ...";.

Line 17-19 & 23-26: The references of measurements from other satellite instruments are necessary to verify measurements from those satellite instruments and to show their recent trends. These references are included to be inclusive.

Line 23-26: As suggested by the referee, a new section called "1.1 Problems with the standard DOAS retrieval" gets started. The following paragraph has moved before section 2 in the revised manuscript; "However, the Standard DOAS (called SDOAS here) retrieval of SO<sub>2</sub> from satellite measurements in the UV wavelength range are in difficulties for e.g., a spectral interference of the SO<sub>2</sub> and ozone absorption signals (for details see section 2). To improve the SO<sub>2</sub> retrieval, the Weighting Function Differential Optical Absorption Spectroscopy (WFDOAS) method was applied here. In the following, we present problems with the Standard DOAS retrieval and the concept of the WFDOAS retrieval. Section 2 describes SCIAMACHY SO<sub>2</sub> retrievals with SDOAS and WFDOAS. In section 3, the results from the two techniques are compared and the effect from different Ring parameterizations is evaluated. In this study we concentrated on selected scenarios with anthropogenic and volcanic emissions as well as background conditions in December 2006. The air mass factor (AMF) calculation to convert the slant columns (SC) to vertical columns (VC) is not covered here, but will be considered in future work."

Line 28: "the" has been removed before "GOME".

page 10820

Line 8, 10 & 22: Comma has been added in "sector, which", "cross-sections, indicating" and "surface, such".

Line 10: "its changes" has changed to "these variations".

Line 20: "... interference from Ring but ..." has changed to "... interference with Ring effect, the 'filling-in' of solar Fraunhofer lines in the scattered light, but ...".

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Line 24: "Overall the scatter in ..." has changed to "The overall scatter in ...".

Line 25: "... large impact over an area ..."; has changed to "... large impact in an area ...".

page 10821

Line 2: " but this reduces " has changed to "but that reduces ".

Line 2/3: As suggested by the referee, a new section called "1.2 Concept of the WF-DOAS retrieval" gets started.

Line 21: The sentence has been removed.

Line 25: "the" before "SCIAMACHY" has been removed.

Line 25-27: The sentence has been replaced with "Section 2 describes SCIAMACHY SO<sub>2</sub> retrievals with SDOAS and WFDOAS. In section 3, the results from the two techniques are compared and the effect from different Ring parameterizations is evaluated."

page 10822

Line 2: The title of section 2 has changed to "Measurement data and retrieval methods".

page 10823

Line 11: The phrase has replaced with "applied to the retrieval of".

Line 14: "(see Table 1)" has been added at the end of the sentence.

Line 15: New paragraph starts here in the revised manuscript.

Line 16: "was" has changed to "is".

Line 17: The typo has been corrected.

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Line 21: "the" before "BrO" and "SO<sub>2</sub>" has been added.

Line 22: added brackets.

page 10824

Line 10: Present tense has been used.

Line 17: The phrase has changed to "taken from the IUP climatology".

page 10825

Line 17/18: "further" has been removed.

page 10826

Line 14, 22: The sentences have changed as the referee suggested.

page 10827

Line 9/11: The sentences have changed as the referee suggested, and changed to "The polynomial degrees and BrO do not have affect on SO<sub>2</sub> slant columns in the WFOAS retrieval, not contributing the differences between SDOAS and WFOAS retrievals. However, both the third order polynomial and BrO in the fit lead to less fit residual in the WFOAS retrieval.".

Line 12, 16, 23, 28: The authors have changed them as the referee suggested.

page 10828

Line 3, 4/5, 6, 20, 23, 26: The authors have changed them as the referee suggested.

page 10829

Line 8: The word "demonstrated" would be appropriate in section of Conclusions.

Line 11: The comma before "and ambient" has been removed.

Line 16: "The retrieval of SO<sub>2</sub> emissions (in particular volcanic SO<sub>2</sub> emissions)" has

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been replaced with "The measurements of SO<sub>2</sub> (in particular volcanic SO<sub>2</sub> emissions)".

pages 10830-10834

References section has been checked. Lamsal et al. (2007), which is not cited in the text, has been removed from reference list. The following references, which are cited in the text, have been added into reference list: "Chance, K.: Analysis of BrO Measurements from the Global Ozone Monitoring Experiment, Geophys. Res. Lett., 25, 3335-3338, 1998.", "Richter, A., Burrows, J. P.: Tropospheric NO<sub>2</sub> from GOME measurements, Adv., Space Res., 29, 1673-1683, 2002.".

page 10835: Table 1

Table 1 of the revised manuscript first mentions SDOAS.

The wavelength range needs to make sure that the wavelength range for SDOAS and WFOAS are the same.

BrO is included in the fit to reduce the fitting residual in WFOAS. The fit including BrO leads to smaller residual, but does not affect on SO<sub>2</sub> slant columns. Also, the number of polynomial does not have an affect on SO<sub>2</sub> slant column, but the polynomial of 3rd order lead to a little less residual in WFOAS fit.: The sentences in line 7-12 has changed to "The polynomial degrees and BrO do not have affect on SO<sub>2</sub> slant columns in the WFOAS retrieval, not contributing the differences between SDOAS and WFOAS retrievals. However, both the polynomial of 3rd order and BrO in the fit lead to less fit residual in the WFOAS retrieval.".

The table has changed as the referee suggested.

page 10836, Fig. 1

Please see the description on "page 10835" above.

page 10837, Fig. 2

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Please see the description on "page 10835" above.

page 10838, Fig. 3

Please see the description on "Regarding Figure 3" above.

The caption has been revised as suggested by the referee.

page 10839, Fig. 4

The "diff" in Figure 4 means the difference between slant columns and the columns over reference sector.

Caption, line 6-7: There is no cloud screening in our WFDOAS retrieval. The WFDOAS retrieval use cloud information for calculation of Ring spectra (Weber et al., 2007). The titles of each panel of Figure 4 has changed as: 'WFDOAS SCIA: 01 -31 DEC 2006', 'SDOAS SCIA: 01 -31 DEC 2006', 'BRD OMI: 01 - 07 DEC 2006', and 'SDOAS SCIA RSM-Corrected: 01 -31 DEC 2006'. The caption of Figure 4 has also been revised to "Figure 4. Global maps of SO<sub>2</sub> slant columns averaged over December 2006. The panels show SO<sub>2</sub> slant columns from the WFDOAS retrieval (top left), the SDOAS retrieval (top right), the RSM-corrected SDOAS retrieval (bottom right), and the OMI BRD algorithm (bottom left). In the area of the Southern Atlantic Anomaly (SAA), large scatter in WFDOAS and SDOAS SCIAMACHY SO<sub>2</sub> results from exposure of the instrument to radiation and particles. RSM: Reference sector method (Martin et al., 2002; Richter and Burrows, 2002). There are the open areas in WFDOAS retrievals due to no SACURA data and in the BRD OMI retrievals due to cloud-screening."

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Interactive comment on Atmos. Chem. Phys. Discuss., 8, 10817, 2008.

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