

***Interactive comment on “Direct sun and airborne
MAX-DOAS measurements of the collision
induced oxygen complex,
 O_2O_2 absorption with
significant pressure and temperature differences”
by E. Spinei et al.***

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Received and published: 19 December 2014

We greatly appreciate the comments from reviewer 2. The referee's comments are marked with Com# and our responses with Res#.

Scientific Significance The scientific significance of this work is high, especially for the DOAS community. This study describes a thorough investigation of the temperature

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and pressure dependence of the O_2O_2 absorption cross section based on data obtained under atmospheric conditions with two very different measurement techniques: ground-based direct-sun DOAS and airborne MAX-DOAS (measurements between 9 and 13.2 km). Noteworthy is the fact that only the second of the two methods requires RTM.

The work is especially relevant in relation to ground-based MAX-DOAS observations, although such observations are not included in this work. The relevance lies in the fact that several groups working with MAX-DOAS found the need to apply a correction factor in order to bring simulations and measurements of O_2O_2 differential slant columns into agreement. This correction factor is introduced for practical purposes and suggests that either the physical understanding of the measurement process (RTM, instrument simulator) is incomplete or possibly that correction factors compensate for errors caused by simplifications (for practical purposes) of the RTM and subsequent analysis.

Application of this scaling factor is undesirable since it causes uncertainty about the MAX-DOAS products where O_2O_2 observations play a role, most notably the aerosol products (e.g. AOT, extinction profile estimate) but also products which rely on cloud filtering or air mass factor calculations for trace gases after an aerosol extinction profile has been estimated. The work presented in this manuscript gives direction to the search for the origin of this correction factor, because it can now be excluded that errors in the O_2O_2 cross section are the main cause.

Scientific Quality The scientific quality of the paper is high. A strong aspect is the fact that two very different techniques are used and that results are compared with laboratory observations. Instruments used are of high quality. Observation strategy is well chosen. A thorough error analysis is presented.

Presentation Quality The presentation quality of the paper is good. Only the visibility of some of the figures could be improved, see below.

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Technical Corrections (minor corrections)

Com1: p.10017 l.26-27: Please make notation more consistent: replace "O₂O₂ \sigma" and "sigma" by "\sigma(O₂O₂)" Also at other places throughout the document.

Res1: We have corrected all instances of \sigma(O₂O₂) including CD, SCD, etc

Com2: p. 10018 l. 21-23: Please add to this sentence that the vertical profile of oxygen is usually quite well known.

Res2: We have modified the sentence for: "The advantage of O₂O₂ for such measurements is that its concentration is directly proportional to the square of the oxygen concentration (R₁), which is well known as a function of altitude."

Com3: p. 10031 l. 21-22: "To investigate.... " This line is possibly confusing. What is to be investigated: the effect of changing surface pressure on the O₂O₂ VOD, or the effect of pressure on the O₂O₂ absorption cross section?

Res3: Please note section 4.2 has been modified overall. We have rephrased the 1st sentence to make it more clear: "To investigate the effect of pressure on $\sigma(\text{O}_2\text{O}_2)$ and whether higher absorption is observed at pressures within PBL at different AMF, we used the DS Fraunhofer spectra collected over TMF at 2.3 km asl (7 July 2007) and over WSU, Pullman, WA at 680 m asl (11 Sept 2007) as reference spectra to analyze the spectra measured over GSFC, Greenbelt, MD at 90 m asl (23 May 2007) with similar T_{eff} (267K \pm 2K). "

Com4: p. 10032 l. 26: Please remove "of the" in "of the of the AMAX-DOAS"

Res4: We have made the change.

Com5: p. 10035 l. 7-8: Please rephrase. Suggestion: "When making a DOAS fit with O₂O₂ cross sections at two temperatures (203 and 293 K), the temperature dependent bias in the measured VCDs is essentially zero within errors at 477 nm."

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Res5: Thank you for the recommendation. We have made the change

Com6: p. 10035 l. 10-11: "(results including aerosol are better compared to the Rayleigh case)" Please explain this remark in some more detail in a separate sentence.

Res6: We have expanded this statement to: "results including aerosol are better compared to the Rayleigh case due to some contribution of O₂O₂ absorption from low altitudes to the measurements at high altitude."

Com7: p. 10035 l. 10-11: "The UV region, ... (203 and 293 K)." Please rephrase the last part of this sentence. E.g. replace "using the two \sigma" by "using O₂O₂ absorption cross sections at two temperatures"

Res7: We have made the change.

Com8: Table 1: Please include Vlemmix et al. AMT(2011). In this study a correction factor of 0.8 was used. Atmos. Meas. Tech., 4, 2659–2684, 2011 (see page 2667).

Res8: Thank you for pointing to this reference we have included it into Table 1.

Com9: Table 2: Please include 'Mean' at the beginning of the caption. "Mean O₂O₂ vertical column density "

Res9: We have made the recommended change.

Com10: Figure 6: open circles representing WSU are poorly visible. Please find alternative that is better visible.

Res10: We have modified the figure to make all the measurements more visible

Com11: Figure 7 could be improved in terms of layout by increasing the thickness of the box around the figures (A) and (B) and by using thicker lines for the open symbols (e.g. the open squares and triangles are quite poorly visible).

Res11: We have modified the figure to make all the measurements more visible

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