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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Measurements of O_3, NO_2 and BrO at the Kaashidhoo Climate Observatory (KCO) during the INDOEX (INDian Ocean EXperiment) Campaign using ground based DOAS (Differential Optical Absorption Spectroscopy) and satellite based GOME (Global Ozone Monitoring Experiment) data" *by* A. Ladstätter-Weißenmayer et al.

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Interactive comment on "Measurements of O3, NO2 and BrO at the Kaashidhoo Climate Observatory (KCO) during the INDOEX (INDian Ocean EXperiment) Campaign using ground based DOAS (Differential Optical Absorption Spectroscopy) and

satellite based GOME (Global Ozone Monitorino Experiment) data" by A. Ladstätter-Weißenmayer et al. Anonymous Referee 2 Received and published: 19 November 2006 This paper presents measurements of O3, NO2 and BrO at the Kaashidhoo Climate Observatory during the INDOEX Campaign using ground based dual-axis DOAS and satellite based GOME data. The paper validates GOME total column observations of O3 and NO2, against ground based measurements. The GOME O3 tropospheric columns derived by the Tropospheric Excess Method are validated against ozonesonde observations. In addition to the GOME validation, i) a pollution event has been followed by the ground based dual-axis DOAS observations as well as by GOME and ii) the presence of BrO in the troposphere is highlighted and an upper limit of the tropospheric BrO column is derived from GOME. Scientifically, the results from the INDOEX campaign that the manuscript presents are definitely worth publication in ACP, however the manuscript requires some (easy) restructuring to facilitate reading, improve clarity and highlight the messages to the reader.

Specific comments:

Abstract page 9274, line 26: where do the authors find information on BrO 'throughout the year' the moment the reported observations are for summertime.

We corrected this part to "over long periods of the year" to explain that BrO measurements were carried out over long periods of the year.

1. Page 9274, last line: provide estimated detection limit in the abstract.

We added the detection limit for BrO to the abstract.

2. Page 9275: line 26: for multi axis DOAS, I have personally found very educative the paper by Hönninger et al., Atmos. Chem. Phys., 4, 231-254, 2004, www.atmos-chemphys.org/acp/4/231/ and therefore, I believe it is worth citation in the introduction of the paper as well as later on in page 9281, line 17.

This is really a very useful reference. For this reason, we added it in the introduction.

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3. Page 9276, line 2: ’enables’ should be in plural.

We replaced ‘enables’ by ‘allow to distinguish’

4. Page 9276, line 5: replace ’were to be’ by ’have been’

Done

5. Page 9276, lines 7-9: rephrase to make clear : ’validation’ of what ? and also the purpose of the synergistic use of ground based observations remotely sensed GOME data and O3-sonde measurements.

This sentence was rephrased as follows: The subject of this contribution is the validation of remotely sensed GOME data with ground based and O3-sonde measurements above the Indian Ocean during INDOEX and also the synergistic use of all these measurements to exploit the advantages of the different methods (such as their different spatial and temporal resolution) to allow the best possible interpretation.

6. Page 9277, line 21: replace ’separated’ by ’deduced’

Done as requested.

7. Page 9279, line 10: remove ’a collection of’

Removed as suggested.

8. Page 9279, line 15: Explain the choice of using a potential vorticity of 4 as threshold and not 3.5, 3 or even 2.5.

In this study a combined criteria based on the potential vorticity (PV) and the potential temperature was used. The height of the tropopause was determined by using the lower most altitude of both criteria. The comparison of the results using PV 3.5 or PV 4.0 showed a very small difference of the geometric height. A good agreement for the results of tropospheric O3 columns between GOME and sonde was obtained when using the potential vorticity of 4.

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9. Page 9280, last sentence of section 3.1: Please explain the significance of this model result, a kind of mid-term conclusion.

As pointed out by one of thee reviewers, there has been a mix-up with respect to the measurement times in the original paper, both in the figure and in the numbers. After correcting this, model and measurement now are in good agreement and the text has been changed accordingly. As expected, the model output shows an almost linear increase of 8*1013cm8722;2/h during the times of ground based and GOME measurements. This value is in good agreement with the result calculated from the ground based measurements (1*1014cm8722;2/h).

10. Section 3.2: I suggest break down this section in 3 sub-sections: O3, NO2 and BrO, respectively since there is no obvious scientific link in these 3 parts except that the same instrumental approach is used. The authors might choose to link better the discussion on the 3 different molecules.

This is a very helpful comment. We broke down this section in three sub-sections: Tropospheric columns of O3, Tropospheric columns of NO2 and Tropospheric columns of BrO.

11. Page 9281, line 22: 'In this study...' start a new paragraph (sub-section on NO2).

As explained above, we separated the section, thus one section: 'Tropospheric columns of NO2' exists.

12. Page 9282, lines 11-12 and line 16: maximum should be 1 or 2 x1E15, can not be 1-2x1E15

We corrected the typo - it should read 1.2x1E15 molec cm-2.

13. Page 9282, line 23: 7x1xE15 correct to 7xE15

Corrected.

14. Page 9282, last paragraph: Could the authors comment on the sensitivity of the

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satellite based and the ground based sensors to the different part of the troposphere (boundary layer/ free and hight troposphere) and how this affects or not the comparison of the results?

As the reviewer points out, the vertical sensitivity of the two measurement systems is different. The ground-based DOAS has a very good sensitivity to the lowest part of the atmosphere while the satellite sensitivity decreases to the surface. However, this is at least in part compensated by using appropriate airmass factors in the GOME retrieval. Given the short duration of the NO2 pulse observed, it is to expected that this was a rather localised pollution plume (probably from a ship) and the large GOME pixel (320 x 40 km2) will dilute such a plume below the detection limit. We have added a short discussion of this point to the paper.

15. Page 9283, line 2-5: Provide location coordinates over which GOME measurements of NO2 have been retrieved.

We changed this part as follows: From GOME measurements the mean background tropospheric amount of NO2 was determined to be 4*1014 molecules cm-2, while the mean total column amount of NO2 during the INDOEX campaign was 1.7*1015 molecules cm8722;2 (both values for the above mentioned region of 300 km around KCO).

16. Page 9284, line 2: 'small amount of BrO' whereas in the abstract page 9274, line 25, it is mentioned 'large tropospheric contributions to BrO budget'. Is there something I miss?

We modified this sentence as follows: GOME measurements showed evidence for small tropospheric contributions to the BrO budget, probably located in the free troposphere and present over long periods of the year. In section 3.4 I corrected 'Very large BrO columns' to 'Tropospheric BrO'.

17. Page 9284, last 2 lines and first 2 lines in page 9285: this sentence requires

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rephrasing for clarity.

We rephrased the sentence as follows to make it clearer:

Differences of up to 40

18. Page 9185, lines 13-19: I would move this discussion on BrO earlier in the conclusion in page 9284, line 14 and finish the conclusion with a kind of perspective for future studies.

We have taken up the suggestion of the reviewer and have reorganized the conclusions section.

19. Page 9295: figure 5: why is there only one point from ground based NO2 observations? To support the discussion on pollution events, at least a few more ground based observations of NO2 should be shown.

In section 3.2 we already explained ('The following comparison shows the results of two selected case studies, for which the atmospheric circumstances were especially favourable for the DOAS technique, were chosen.') the very difficult atmospheric circumstances which finally led to a small data set based on ground based measurements for tropospheric trace gases like O3 and NO2.

20. Page 9296: figure 6: are there any BrO ground based observations? If yes, they whould be shown in Figure 6.

In section 3.4 we gave a detection limit of 3*1014 molecules cm8722;2 for tropospheric BrO from the ground based dual-axis-DOAS measurements. Unfortunately, this value is above the upper limit of 3.8*1013 molecules cm8722;2 from GOME measurements. For this reason, addition of the ground based observations BrO upper limits will not provide any additional information.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 9273, 2006.