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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 Monitoring Experiment) data" by A. Ladstätter-Weißenmayer et al. Anonymous Referee 3 Received and published: 18 November 2006 The paper is presenting measurements of three different trace gases using three different measurement techniques: ground based dual-axis DOAS for O3, NO2 and BrO, GOME satellite measurements for O3, NO2 and BrO and O3-sondes. The presented measurements taking place at the Kaashidhoo Optical Observatory present a very important contribution to the INDOEX campaign. The paper is well structured and well written. Therefore I recommend its publication in ACP after the authors have addressed a couple of specific issues noted below. Specific issues and technical corrections

Title: The title is really long, how about shorten it by leaving out the acronyms or by using the acronyms only?

We have shortened the title as follows: Measurements of O3, NO2 and BrO during the INDOEX campaign using ground based DOAS and GOME satellite data

Abstract: Sentence starting in line 21: you can change "background conditions were observed most of the time" to "mainly background conditions were observed"

Modified as suggested by the reviewer.

Next sentence: you can change "In the GOME measurements, evidence was found for..." into "GOME measurements showed evidence for ..."

Modified as suggested by the reviewer.

Next sentence: it is not clear what "the latter" refers to. The study using measurement conditions with high and low clouds to determine the detection limits should be described in a little more detail, not necessarily in the abstract, but in Sec. 3.2.

We modified the sentence to 'The amounts of BrO have been investigated by the comparison of satellite pixels influenced by high and low cloud conditions based on GOME data which allows the determination of the detection limit of 3.8*1013molecules

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cm8722;2 of tropospheric BrO columns. In addition in section now 3.4 (earlier section 3.2) the method to determine the tropospheric amount of BrO from GOME is described in more detail: ‘Using the difference of the slant columns of BrO retrieved at low (at 900-1013 mbar) and high cloud (at 0-600 mbar) situations during the INDOEX campaign an upper limit for the free tropospheric column of BrO of 3.8*1013molecules cm8722;2 from GOME pixels (see Fig. 6) can be observed.

Introduction: Acronyms only have to be spelled out the first time they are used, INDOEX was already spelled out before, as well as KCO, DOAS and GOME.

We now introduce the acronyms KCO, DOAS and GOME in the abstract and are not introduced again in the introduction

The Page 9276, line 2: please change "...enables stratospheric and tropospheric amounts of atmospheric gases to be distinguished." to "...allows to distinguish stratospheric and tropospheric amounts of atmospheric gases."

The sentence was changed to: ‘Simultaneous measurements of zenith-sky and off-axis scattered sunlight allow to distinguish stratospheric and tropospheric amounts of atmospheric gases.’

Next sentence: you can change "Specifically" to something like "In this case"

We modified the sentence as follows: ‘In this case the total and tropospheric column amounts of ozone (O3), nitrogen dioxide (NO2), as well as tropospheric amounts of BrO above KCO have been investigated.’

Section 2.1: What is the difference between the "absorber amount in the background spectrum (SC0) at the smallest solar zenith angle" and the zenith sky measurement? You are saying that SC is the sum of DSC and SC0, and DSC is the "column amount of the absorber integrated along the light path through the atmosphere" minus SC0, so SC is equal to SC0, right? The whole section could need some clarification, it is not clear which values are calculated and which are measured. Do you use the zenith sky

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spectrum as the solar spectrum for the DCS DOAS fit, or do you perform two DOAS fits, one for the zenith sky and one for the off-axis measurement? In the first case how do you derive the total SC? In the second case you should mention which solar references you are using.

To answer both comments we modified the sentences in the paper to make it more clear.

For this study, spectra in the wavelength region of 435-481 nm were analysed applying the DOAS technique (Platt, 1994), (Wittrock et al., 2004), (Heckel et al., 2005) to obtain the differential slant column (DSC). The DSC is the difference between the column amount of the absorber integrated along the light path through the atmosphere at the time of measurement (SC) and the absorber amount in the background spectrum (SC0). For the background spectrum, a zenith measurement at high sun taken on the same day was used for both zenith-sky and off-axis observations.

Section 2.2: First sentence: you can leave out "second". You might want to add "and partially absorbed" after "scattered".

We removed ‘second’ but didn’t add ‘partially absorbed’ because absorbed light can not be measured from e. g. GOME nor from the dual DOAS ground based instrument.

Sentence starting in line 21: the "-" can be replaced with ",". Please replace "influence of trace gases below the cloud layer" with "trace gases amount below the cloud layer".

Replaced as suggested by the reviewer.: ‘GOME observes both, the troposphere and the stratosphere (Burrows et al., 1999), and in cloudy conditions it is impossible for GOME to detect the exact trace gases amount below the cloud layer.’

Figure 3: Since Fig. 3c suggest that the DOAS a.m. and p.m. NO2 values can be linearly interpolated to GOME overpass time, you could add interpolated ground based data points to Fig. 3b so that those points can be directly compared to the GOME data. The labels on the time axis of Fig. 3c is very confusing, does Mar-20,2

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mean March 20th and 0.2*24h (plus 5 h for the time zone of the Maldives)? If that is the case the time of the DOAS a.m. measurement seems to be 8:12 instead of 6:30, the GOME overpass time 9:50 instead of 10:30 and the DOAS p.m. measurements at 13:00 instead of 17:30. I am also wondering why you are showing more than a day. All three plots are a little bit too small.

We would like to thank the reviewer for pointing out this error. In fact, both the figure and the numbers in the text were mixed up and we corrected this. Figure 3b was modified accordingly and the DOAS a.m. and p.m. values were interpolated to the GOME over pass time (coloured in blue) to make them more comparable to the satellite data. In addition Fig. 3c was modified to the correct local times of the a.m. and p.m. data of ground based measurements and GOME.

Figure 4: Please explain how the dotted line was calculated, why the sdev is not provided for all data points, and why the sonde data is sometimes outside the sdev boundaries.

Fig. 4 was modified to make the uncertainties of the sonde measurements more clear.

Section 3: You are mentioning ground based BrO measurements in the title, but only GOME BrO data is shown in the paper, so I suggest that you either show some ground based BrO data, or focus on O3 and NO2. Would it be possible to show more than two ground based measured values for tropospheric O3 (Fig. 4) and NO2 (Fig. 5b)?

Results from all three different trace gases (NO2, O3, and BrO) are shown in the paper. For BrO a detection limit was given for ground based measurements and an upper limit for the GOME measurements. As the detection limit of the ground based measurements was too high for tropospheric BrO as follows no results can be shown. Caused by the atmospheric circumstances only some selected case studies which were especially favourable for the DOAS technique, were chosen, as described in the paper.

Conclusions: Please explain how you quantified the "theoretical errors" (line 18).

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We modified the text as follows: ‘The relatively large errors in the ground based data are related to the assumed homogeneity of the tropical air masses encountered.

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