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Interactive comment on "Pole-to-pole validation of GOME WFDOAS total ozone with groundbased data" *by* M. Weber et al.

M. Weber et al.

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We thank anonymous reviewer 3 for his comments and suggestions to improve the paper.

Major comments:
1) The reviewer wants to have the advantages of WFDOAS over GDP V3 more clearly summarised in the abstract and introduction. We have changed the beginning of the abstract as follows: *This paper summarises the validation of GOME total ozone retrieved using the weighting function differential optical absorption spectroscopy (WFDOAS) algorithm Version 1.0. This algorithm has been described in detail in a companion paper by Coldewey-Egbers et al. (2004). Compared to the operational GDP (GOME Data Processor) V3, several improvements to the total ozone retrieval have*

been introduced that account for the varying ozone dependent contribution to rotational Raman scattering, includes a new cloud scheme, and uses the GOME measured effective albedo in the retrieval. Further down: *From the global validation excellent agreement between WFDOAS and ground data was observed and on average agree to within ±1%. Very little seasonal variations in the differences are observed. In the polar regions and at high solar zenith angles, however, a positive bias varying between 5 and 8% is found near the polar night period that is similar to earlier GOME data version. As a function of solar zenith angle as well as of the retrieved total ozone, the WFDOAS differences to ground polar data, however, show a much weaker dependence as compared to prior data version of GOME that represents a significant improvement.* In the Introduction we have modified the third paragraph as follows: *In a companion paper (Coldewey-Egbers et al. 2004) a new total ozone retrieval algorithm has been introduced that uses the Weighting Function Differential Optical Absorption Spectroscopy (WFDOAS) approach. It introduces several new features that have not been used in prior total ozone retrieval from GOME. The variable ozone dependent contribution to the Raman scattering responsible for the filling-in of molecular absorption is properly accounted for. The use of a new cloud scheme in combination with an estimation of effective scene height lead to higher sensitivity to clouds in WFDOAS. In addition, the GOME retrieved scene albedo is included in the retrieval. It was already shown in the companion paper that these new features have improved the total ozone retrieved from GOME compared to earlier retrieval versions. This paper describes the validation of WFDOAS with groundbased data on a global scale. Comparison of operational GDP (GOME Data Processor) V3 to ground data are also presented to document the significant improvement achieved by WFDOAS over prior data version.*

2) Why was the GOME validation limited to 1996-1999 period (with exception of Lauder and Hohenpeissenberg)? Please see response to major comments of Reviewer 1 that lead also to rearrangements of some part of the paper and new figures replacing Figs. 8 and 9.

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Specific comments:

Introduction. see response to major comment. p. 6912, line 18. Have added comment to the profile shape climatology: *This climatology accounts for seasonal variation and also contains typical ozone hole profiles.*

p. 6915, line 19-26. Regarding the advantage of Brewers over Dobsons, see response to major comments by Reviewer 2.

p. 6916, lines 15-16. limited period considered for validation: see response to major comments by Reviewer 1.

p. 6918, lines 7-8. The reviewer questions the selection criteria by excluding biassed data: Only a few stations were excluded that showed unusual behaviour. They were a few Indian stations and data from Hanoi, Vietnam. The text in the first paragraph of Section 4 has been changed as follows: *Only those stations have been selected that show no larger gaps in time and should not suffer from unreasonable short time jumps and do not have an average bias clearly exceeding 5%. Those excluded were mainly some Indian stations and Hanoi, Vietnam.*

p. 6918, line 11. Why were different collocation radii of 160 and 300 km used? From our experience from many validation exercises it was found that a comparison is not changed for collocation radii by up to 500 km. Beyond 500 km, the more significant changes are in the RMS scatter of the differences. Since only the nearest collocation at a given day was selected, only few data are added from increasing the maximum allowable collocation radius. In the first paragraph of Section 4 the following was added: *A change of collocation radius to 300 km rather than 160 km as in the case of the triple comparison presented earlier does not alter the statistics significantly.* One should also note that for the majority of GOME data the footprint is 320 times 40 km, so that the collocation radius choice is not so critical here.

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p. 6918, l 21ff. It was suggested to emphasize more strongly the improvement by WFDOAS. In the revised Section 5 we have added the following paragraph to the text to highlight this point: *An important result from this validation is, nevertheless, that the seasonal dependence in the GOME-ground based data differences is quite small and gets smeared out when averaged over many stations. This is a large improvement compared to GDP V3 that shows a distinct seasonal signatures at mid latitudes that does not average out. Both retrievals, WFDOAS and GDP V3, use the TOMS V7 profile shape climatology (GDP V3 uses the climatology for airmass factor calculation). The big improvement in WFDOAS retrieval is that the TOMS V7 ozone profile shape climatology is also used to determine the varying ozone dependent contribution to the rotational Raman correction that is neglected in GDP V3.*

p. 6920, 12-19. Do the European stations not show any seasonal variations in the differences to GOME? This is definitely not the case. see response to previous paragraph.

p. 6921, Fig. 8. Order of panels in figure should be reversed. Figures 8 and 9 have been replaced by new figures that include data up to 2003. See also response to major comment.

p. 6921, lines 16-17. Request for explaining more the bias in WFDOAS at high total ozone and low solar elevation. As part of the re-arrangement of Section 6 (Validation in polar regions) we have made this point more clear. The TOMS3-F comparison campaign showed that under high polar ozone condition like in Arctic spring 2001, the comparison between modified Brewer and Dobsons results taking into account improved stray light corrections and accounting for the proper ozone temperature, showed an average difference to the standard AD pair retrieval of the Fairbanks Dobson of about +3 to +4%. Looking at new Fig. 11, we observe a bias of about +2 to +4% on average between WFDOAS and the results from the six polar stations (five Dobsons and Resolute Brewer) in March/April 2001 in line with the results from the TOMS3-F campaign. This points at the possibility that the WFDOAS bias observed can be at least in parts be

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explained by the shortcomings of the standard retrieval in groundbased instruments.

p. 6922, lines 21-23. this point becomes obsolete with the new figures added.

p. 6923, lines 2-4. Why longterm validation only for Lauder and MOHp? This section on longterm validation has been integrated to the new Section 4. Polar data have been extended to 2003 and we believe that this suffices to show the longterm stability of the WFDOAS retrieval for the extended period. see also response to major comment.

p. 6923, lines 7-10. Why does the seasonal variation in the differences vanishes in the validation with WOUDC data as opposed to the results from the triple comparison? In the revised Section 5 we have added the following paragraph to the text: *The insignificant seasonal variation observed in the WFDOAS differences at low to mid latitudes is in contrast to the conclusion from the triple intercomparison involving collocated Brewer and Dobson data, where a distinct seasonal cycle signature is expected from the lack of ozone temperature correction in the ground based data retrieval. One should keep in mind that other factors influence Dobson results such as stray light errors (reduces retrieved total ozone) and environmental settings (affecting stray light levels) that may differ from station to station. As pointed out earlier, the ozone temperature correction is more important in direct sun measurements than for zenith sky measurements that are also included in the WOUDC data.*

Table 1. The instrument type for each station has been added.

American/British English. We have checked the text and try to follow British English rule, however, we stay with the term fall for autumn.

p. 6911, line 18. Comment on change of Dobsons to Brewers at many stations. in Section 3, the following information has been added: *Since the early eighties Brewer grating spectrometers have been installed at several stations (Kerr et al., 1985) and at many stations Dobson instruments have been replaced by Brewer spectrophotometers or are planned to be replaced.*. Also: *Particular advantage of the Brewer is its fully*

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automated operation.

All other specific comments have been agreed upon in most cases and changes were made as suggested.

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 6909, 2004.