Atmos. Chem. Phys. Discuss., 6, S3736–S3740, 2006
www.atmos-chem-phys-discuss.net/6/S3736/2006/


Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Improved ozone profile retrievals from GOME data with degradation correction in reflectance" *by* X. Liu et al.

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Received and published: 13 October 2006

We are grateful to the constructive comments by M. Weber. We have carefully considered his comments and will address them in the revised version. Our responses to his comments are as follows:

1. Also, there is considerable inter-annual atmospheric variability, particularly for ozone at high latitudes that may affect the results. Probably, a restriction to tropical latitudes (less ozone variability) or icy surfaces (reduced impact from clouds) for determining the ratios may work better.

Response: We initially thought that using measurements in the tropics should work better for the same reason, so we started with the tropical measurements. However, we found that using tropospheric measurements (15S-15N) leads to more oscillating



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features (varying from 0.94-1.06) in the derived degradation curve before 1998 (i.e., when there is not much degradation) than using the measurements between 60N and 60S, and the derived results are less consistent with those by (Krijger et al., 2005) (referred to as Landgraf et al., 2005 in the paper, now changed to their technical report). Including middle and high-latitude measurements works better, probably due to reduced impact of clouds. In addition, there is more distinct seasonality/solar zenith angle variation in the derived ratios so that atmospheric variation due to seasonality and solar zenith angle changes can be more reliably removed. We also compared the effect of using all measurements, the 20% darkest, and the 20% brightest measurements on deriving degradation and found that using all the measurements can better reduce the effect of atmospheric variability. We have not tested the use of measurements over icy surfaces. There are probably inadequate measurements all the year round (there are not many measurements in the winter due to lack of solar illumination) to smooth the atmospheric variability and there is usually more ozone variability over icy surfaces (usually at high latitudes). We will add the following paragraph to explain why we use all measurements between 60N and 60S:

We tried using the GOME data between 15N and 15S to derive degradation in the reflectance, but the derived degradation curve contains larger oscillating features (varying from 0.94 to 1.06) before 1998, when the degradation is insignificant. The less satisfactory result obtained using tropical measurements is probably due to larger impact of clouds. We also compared the effect of using all measurements (60N-60S), with the 20% darkest and brightest measurements and found that using all measurements better reduces the effect of atmospheric variability.

2. In an earlier paper by us (Bramstedt et al., 2003), where we compared total ozone derived from our profile retrieval (as described in Hoogen et al. (1998)) with TOMS, GOME total columns (derived from 325-335 nm), and many Dobson stations, we found that the total column from profile retrieval appears to be rather insensitive to changes in the calibration (see also the total ozone comparison in Fig. 6 of Liu et al.).



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Response: The effect of degradation on total column ozone using our ozone profile retrieval algorithm depends on the degradation in the 327-340 nm region. Figure 2 shows that total column ozone can be affected by up to 6 DU in late 2000 and 8 DU in early 2001, corresponding to large degradation in this wavelength region. Note that the results in Figure 6(a) are almost the same as Figure 2(a) except that Figure 6 uses a subset of retrievals in Figure 2 that collocate with ozonesonde measurements. However, the effect is less visible due to the large y-axis range (from -40 to 40 DU in Figure 6 vs. -15 DU to 15 DU in Figure 2) and some larger biases between retrievals and DOBSON measurements during some periods. The lower sensitivity to degradation of the integrated total column ozone from the FURM algorithm (Hoogen et al., 1999) might be related to different algorithm features (especially related to calibration) or to different fitting windows.

3. For the comparison of the retrieval with and without degradation and with Hohenpeissenberg data, I suggest to add comparisons for individal stratospheric layers (for instance, 9 km wide layers, from 10 km to the burst height of ozone sondes at about 27 km or higher) in Figs. 2, 4, and, in particular, Fig. 6. This way one can better demonstrate how the wavelength dependent degradation correction possibly improves all altitude levels. Using lidar data from Hohenpeissenberg one could even extend the comparisons to higher altitudes.

Response: We initially thought of showing comparison at individual layers and we had plotted such figures. However, it is difficult to visualize how the degradation correction affects the vertical distribution of ozone retrieval because the effect on each layer is shown separately. Thus, we decided to show the monthly mean differences in retrieved vertical ozone profiles (i.e., all altitude levels) between with and without degradation for selected months or latitudes (when/where the degradation is insignificant or significant), i.e., Figs. 2, 4, and 6.

4. Here appears to be a mix-up of two different effects on the cause of the degradation. The etalon effect is mainly related to the ice layer on the detector. The etalon patterns



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(sinusoidal spectral features) normally change (mainly their phase) after cooler switching of the detectors, when the detectors have been warmed to above freezing point. This occured frequently throughout the lifetime of GOME. The actual degradation (lost and gain in intensity) with time is associated with contaminants that fill voids in the MgF2 coating of the scan mirror (Snel, 2000). Those contaminants, which could be water or any other material that has different refractive properties than the coating and Al, are believed to be responsible for the wavelength dependent degradation. They are also believed to produce the observed scan angle dependence in the degradation as discussed by Snel (2000).

Response: We will change the cause of scan mirror degradation to contaminants that fill voids in the MgF2 coating of the scan mirror and change the reference from Tanzi et al. 2000 to Snel, 2000.

5. p. 8290, line 9: How is the tropospheric column defined here? A brief description and a reference to one of the authors' earlier paper would be helpful.

Response: We will add the sentence "Our retrieval algorithm includes tropopause as a retrieval level (Liu et al., 2005), so that tropospheric column ozone (TCO) is directly derived by summing up the partial column ozone in those tropospheric layers" in the revised version.

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