GOMOS bright limb ozone data set by S. Tukiainen et al.

Answers to referee comments, Referee #1 (RC C84).

The authors would like to thank Referee #1 for reviewing the manuscript.

Response to comments

- **General comment - uncertainty estimates** We agree that it is important to discuss the uncertainties related to the individual profiles. We added a figure showing an example of the error bars (from 2004 Equator) and the following discussion in the paper:
  The error covariance matrix of the retrieved densities is estimated at the minimum assuming Gaussian posteriors:

$$\boldsymbol{C}_r = (\boldsymbol{J}'\boldsymbol{J})^{-1}\frac{\chi^2}{(n-p)} \tag{1}$$

  where $\boldsymbol{J}$ is the Jacobian, n is the number of spectral points in the fit, and p is the number of retrieved gases. The error estimates of the retrieved densities are the square roots of the diagonal elements of $\boldsymbol{C}_r$. An example of the ozone profile errors is shown in the left panel of Fig. 1. The relative error (error/density×100 [%]) is 2–15 [%] depending on the altitude, which are quite typical error values for stratospheric ozone profiles. Scaling the covariance matrix with the reduced χ^2 in Eq. (1) leads to more realistic error bars for the profiles. In theory, the reduced χ^2 should be unity but the average χ^2 of GBL is around 0.5 between 20–45 km and the scaling is needed (Fig. 1, right panel). The GBL χ^2 values less than unity indicate some issue in the measurement error characterization.

- **page 989, line 16-17 - typo** Corrected

- **page 990, line 14 - accuracy of the tangent height registration** We say it more precicely now, and cite the original article that gave this estimate:
  One particular advantage of GOMOS is that the tangent height registration is very accurate: of the order of 30 m (Bertaux et al., 2010). Stars are point sources and their positions are well known. Because the GOMOS central band always follows the occulting star, the uncertainty in the tangent height, which is often a significant problem in limb scatter satellite observations, is a negligible issue in the GOMOS retrievals (Tamminen et al., 2010).

- **page 991, equation 2 - why not simpler formula?** The reason for breaking the modeled radiance into two parts $\mathbf{R}$ and $\mathbf{I}_{ss}$ is that the $\mathbf{R}$ is actually taken from a look-up table and kept fixed during the iterations of $\mathbf{I}_{ss}$. This is explained in the previous paper but not in this and it may seem confusing indeed. We try to clarify

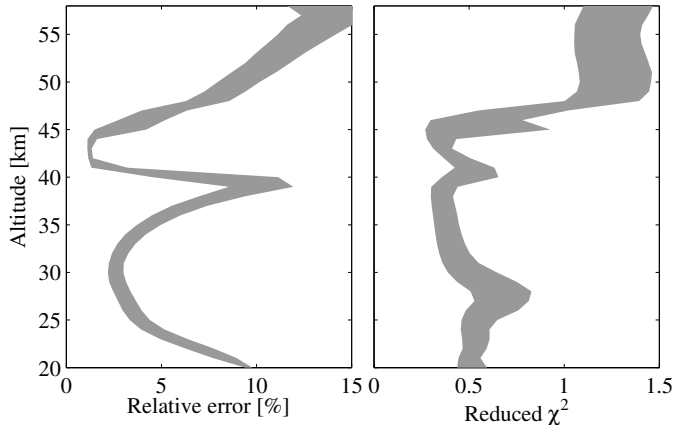

Figure 1: Interquartile range of the relative error (left) and reduced χ^2 (right). Data from the tropics, year 2004.

it now:
The modeled radiance

$$\boldsymbol{H}(\lambda, z) = \boldsymbol{R}(\lambda, z)\frac{\boldsymbol{I}_{\mathrm{ss}}(\lambda, z, \rho)}{\boldsymbol{I}_{\mathrm{ref}}(\lambda)} \tag{2}$$

consists of the modeled total to single scattering ratio $\boldsymbol{R}$*, calculated in advance as a look-up table, and the single scattering radiance* $\boldsymbol{I}_{ss}$ *divided by the modeled reference spectrum* $\boldsymbol{I}_{ref}$*.* $\boldsymbol{R}$ *depends only weakly on the actual trace gas profiles, allowing us to keep it fixed during the fitting process. With this assumption, we only need to solve the single scattering radiance* $\boldsymbol{I}_{ss}$ *which can be effectively calculated using simple numerical integration. The reference spectrum* $\boldsymbol{I}_{ref}$ *is estimated using neutral air from the ECMWF model analysis data (MSIS-90 climatology above 1 hPa) and climatological trace gas profiles.*

- **page 991, line 5 - Why retrieve neutral air?** The modelled reference spectrum is calculated using the ECMWF neutral air and MSIS-90 (see the answer above). So in one sense, the neutral air is used as a priori in the retrieval. Furthermore, it is not practical to fix the air in the upper altitudes, as there are several percent errors in the ECMWF air, and especially in MSIS-90, as well. Also the severe stray light and saturation problems of GOMOS complicate the retrieval of air/aerosols. However, this is something that could be studied more in the future.

- **page 991, line 25 - define CCD** Done.
...the choice of the charge-coupled device (CCD) band of the spectrometer (upper or lower) and...

- **page 990, line 7 - Do not begin sentence with "OR".** We corrected this as suggested:
Since GOMOS records two separate radiance spectra at each tangent height, above and below the central band (which collects the combined star and limb signal), there are actually twice as many spectra.

- **page 992, line 10 - OSIRIS acronym** The acronym is now given in the correct place.
- **page 993 - comparison with SCIAMACHY-limb?** It is true that the SCIAMACHY-limb data could be used in the comparison. There were some issues with the data quality some time ago, but as far as we know they are solved now. However, we decided to use only MLS, GOMOS night and OSIRIS data because we have most experience with these data sets.
- **page 994 - missing OSIRIS reference** We added this reference.
- **page 996 - GOMOS LST** This is now mentioned in section 2.