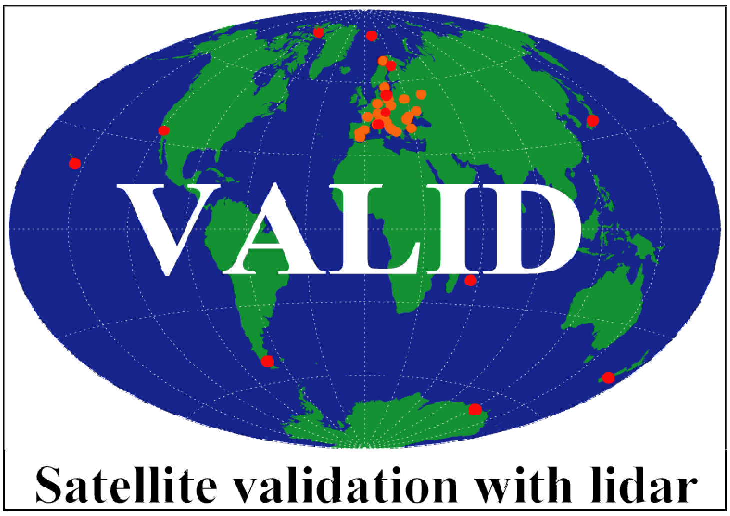
Comparison of GOMOS prototype processor versions 6.0cf and 7.0de ozone profiles with ground-based and balloon-borne measurements



Used datasets and filters

GOPR

Ozone profiles from the GOMOS prototype processor (GOPR) versions 6.0cf and 7.0de have been compared with ground-based measurements. Several data filters were tested:

- maximum error of 30% (matching the ground-based measurements)
- maximum error of 100%.

in combination with

- all ozone values allowed (including extreme and also negative values)
- values limited to positive values below 10^{19} molecules/m^3 (this mainly affects the mean-value/difference plots). Only the parts of the profile outside this range are removed, positive spikes at high altitudes where ozone concentration is lower may therefore still occur, but extremes are removed.

Data are in most cases limited to those having a solar zenith angle > 107°, which we refer to as ‘dark’ measurements. The measurements that have an illumination flag *dark* (flag eq 0) are referred to as ‘Edark’.
In all cases, the processing flag (ozone retrieval, flag eq 0) has been applied.
When matched against microwave radiometer data, the GOMOS data have been smoothened to a resolution of 10 km.

Ground / balloon-based measurements

Balloon borne measurements are smoothened using a running mean to a resolution of 2 km to match the GOMOS resolution. Comparisons with sonde data are done up to an altitude of 30 km.
Lidar data and microwave radiometer are limited to those altitudes where the reported error is <30%. Lidar data are used in the altitude range 18 to 45 km and microwave radiometer data are used from 30 km upwards.

Data result in valid collocation pairs if the difference in time is less than 20 hours with a distance smaller than 800 km. Above 50 km, the time is limited to 5 hours.
GOMOS collocations with microwave radiometer profiles furthermore are rejected if the illumination conditions are not equal (e.g. no microwave observation during bright limb conditions compared with dark GOMOS observation).

The effect of 30% versus 100% error filtering (GOMOS) for GOMOS in combination with star characteristics

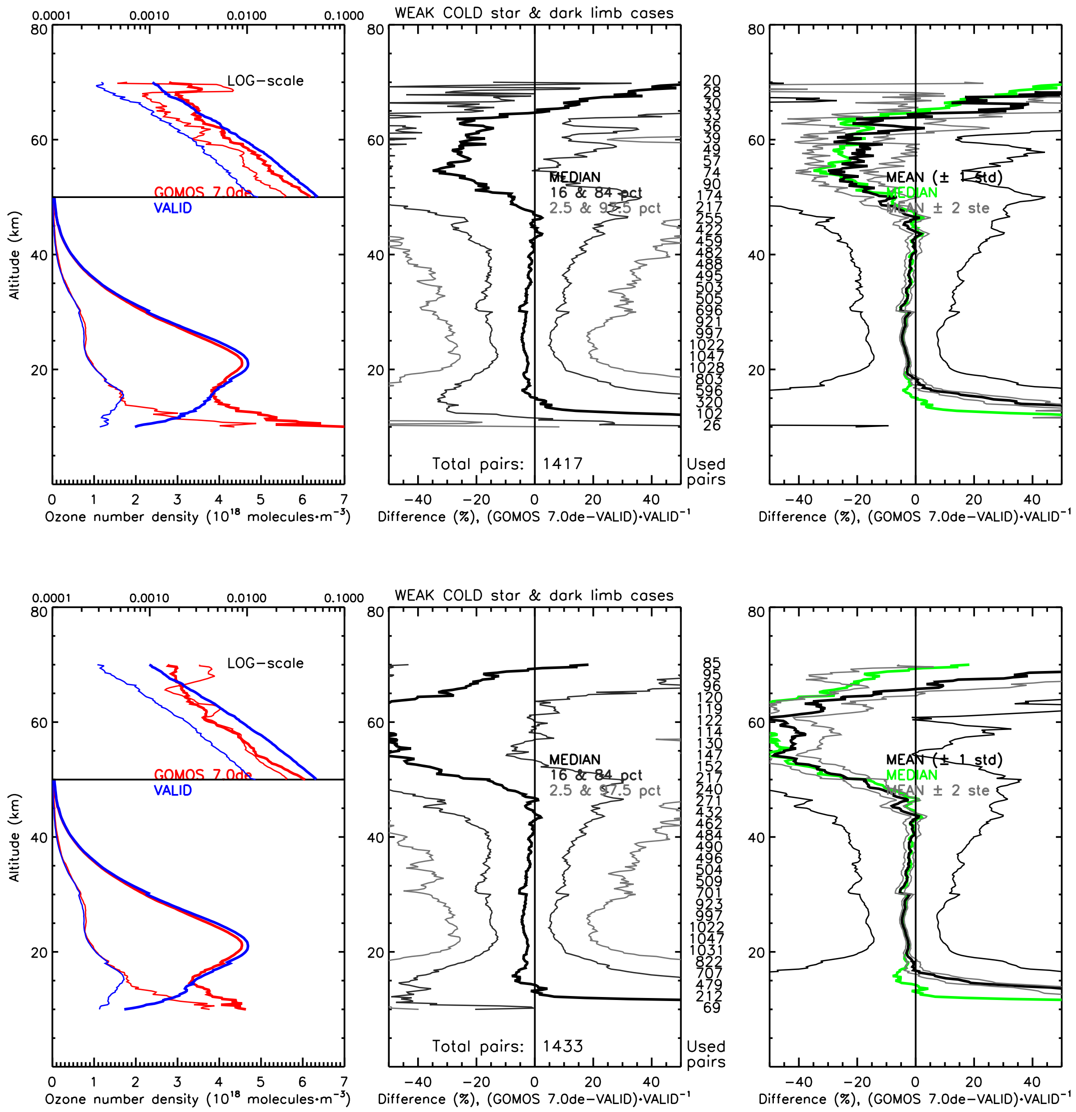


Figure 1. Example of the effect of 30 % versus 100 % error filtering (GOMOS) for GOPR 7.0de observations using weak, cold stars. Top: maximum error of 30 % in GOMOS data; bottom: maximum error of 100 % in GOMOS data

Differences between filtering using a threshold for the reported GOMOS error of 30% in comparison to 100% are illustrated for <u>weak, cold</u> stars processed with GOPR 7.0de in Figure 1.

At lower altitudes a few profiles are added when increasing the allowed error from 30 to 100%. The mean GOMOS and difference profiles improve. In the mesosphere (~ above 50 km) the increase in number of profiles is large given the low amount of profiles for the 30% error case. The mean and median differences are strongly affected here and are often significantly different.

For <u>strong, cold</u> stars, no collocations with microwave radiometer data were found and therefore no comparison is available above 45 km. Increasing the allowed error only adds collocation pairs at lower altitudes and increasing variability in the GOMOS data (spike in standard deviation, not shown).

For weak, hot stars, increasing the error to 100% also affects the lowest altitudes and the effect is an improvement in the match between the ground-based and GOMOS observations (not shown).

For strong, hot stars, the increase of the maximum allowed error is especially visible in the standard deviation, which strongly increases (leaves the plot) between 16 and 20 km as a consequence of the addition of a single profile. Close to 10 km more profiles are added, but the effect is positive (not shown).

The effect of limiting the ozone range in the GOMOS values

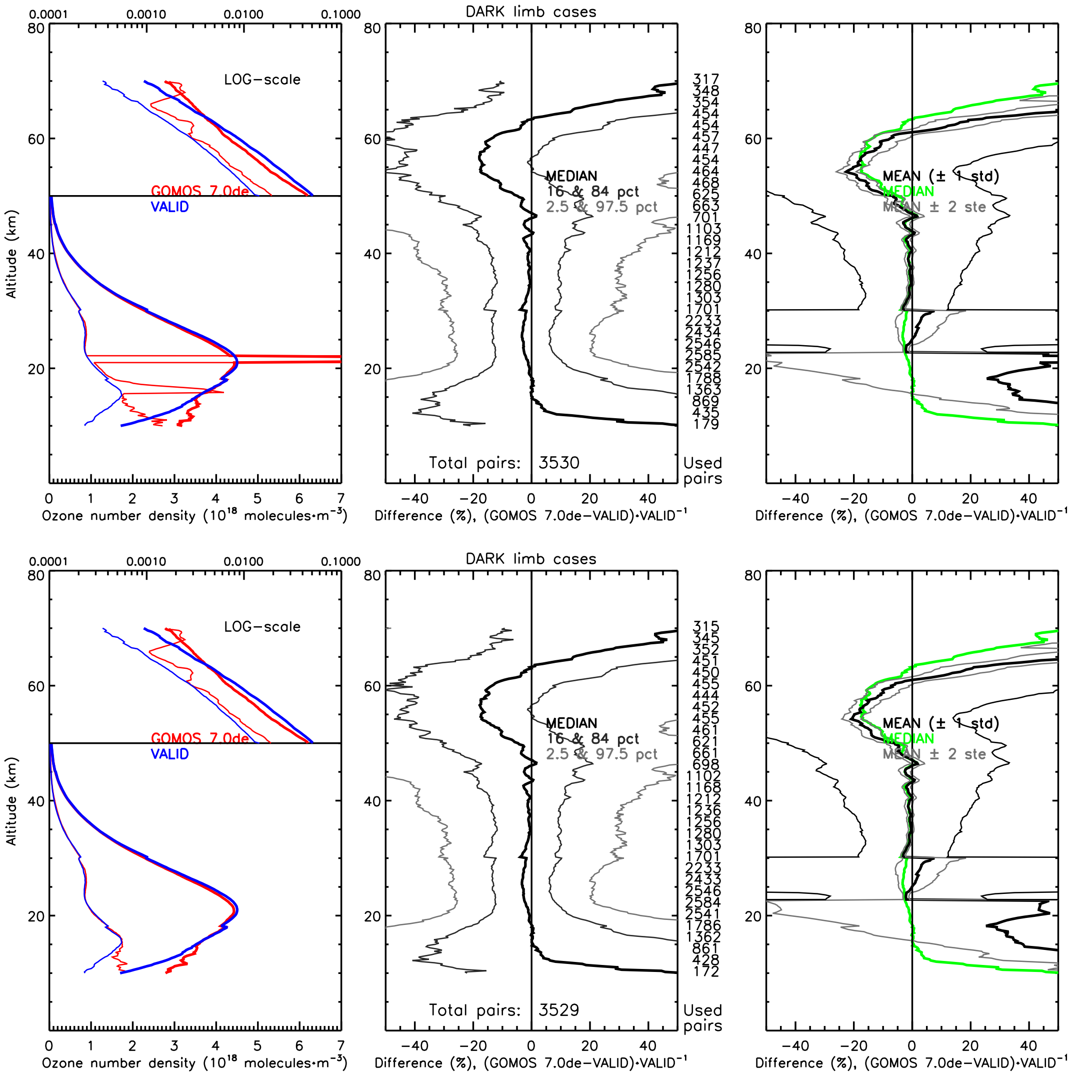


Figure 2. Example of the effect of applying a filter to the ozone values for GOPR v7.0de data with allowed error of 100%. Top: all dark cases; bottom: all dark cases, ozone values outside range [0,10^{19} molec./m^3] removed.

Figure 2 (left panel) shows that the spikes in the GOMOS mean and standard deviation plots can be removed by filtering for extreme values (outside the range 0 to 10^{19} molecules/m^3. A similar effect of filtering for extreme values is seen when the error is limited to 30%. The percentile plots remain virtually the same, indicating the number of these outliers is very small.

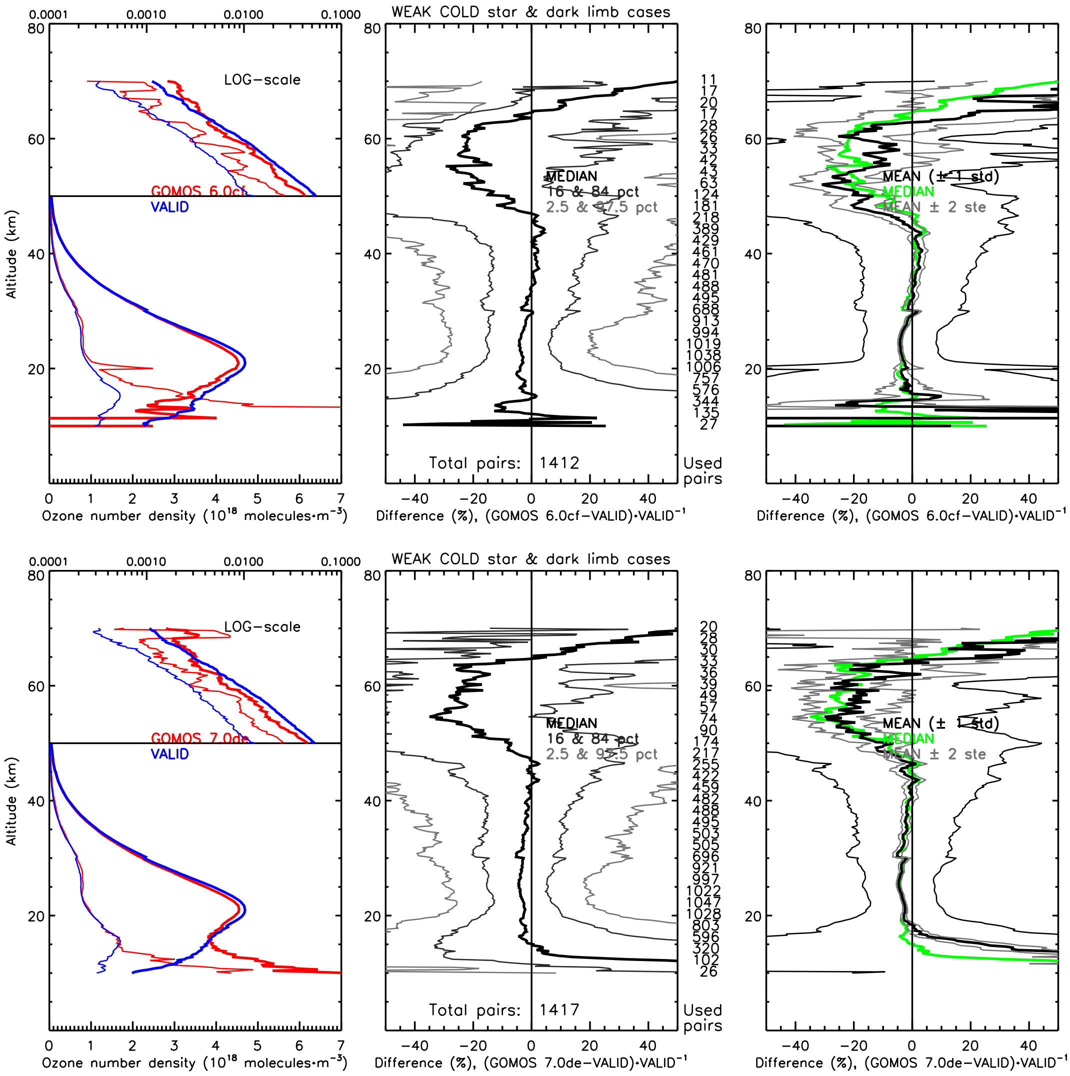


Figure 3. Retrievals using weak, cold stars compared to validation data for version 6.0cf (top) and 7.0de (bottom). Both cases are filtered to have a maximum error of 30 %, but no restrictions are placed on the allowed ozone range.

Although Figure 2 showed that the limiting of the ozone range leads to fewer outliers, Figure 3 shows that retrievals for e.g. cold, weak stars have improved from version 6.0cf to 7.0de. More pairs are accepted and the spike visible in the standard deviation at 20 km for version 6.0cf is removed for version 7.0de.

Polar region on the northern hemisphere

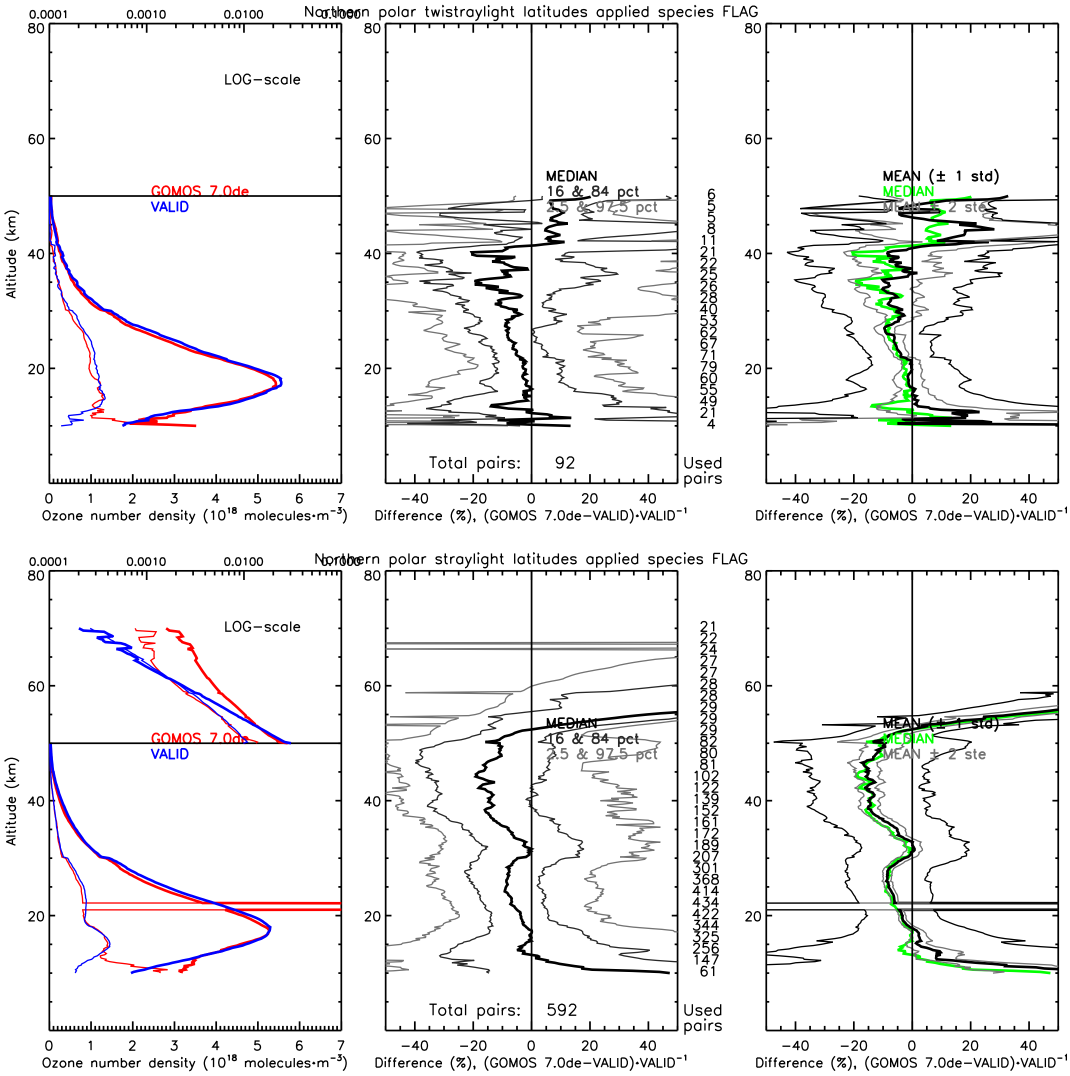


Figure 4. Northern polar region GOPR7.0de ozone profiles with a 30 % maximum error, no O_3 limits. Top: twilight+straylight contaminated profiles. Bottom: straylight contaminated profiles.

Figure 4 shows the results for the polar region on the Northern hemisphere. No Edark collocations are available in this region. Most collocations are with straylight contaminated profiles (lower plot). There is a single profile causing the large peak in the mean and standard deviation plot. For the straylight+twilight contamined profiles there are rather few collocations, especially above 30 km. A negative bias is visible in both plots, reaching up to -20%.

From the analysis of the current ESA level 2 processed data (IPF v5.00), there is some difference visible between data flagged 0 (Edark) and those flagged 2-4 in the latitude region 40 to 50 degrees north, with the non-dark data giving a more negative bias, but the difference is not yet significant. The available Edark dataset is also rather small (at most 70 collocated pairs for a given altitude). All data are from the dark limb in the sense that they are taken for solar zenith angles > 107°.

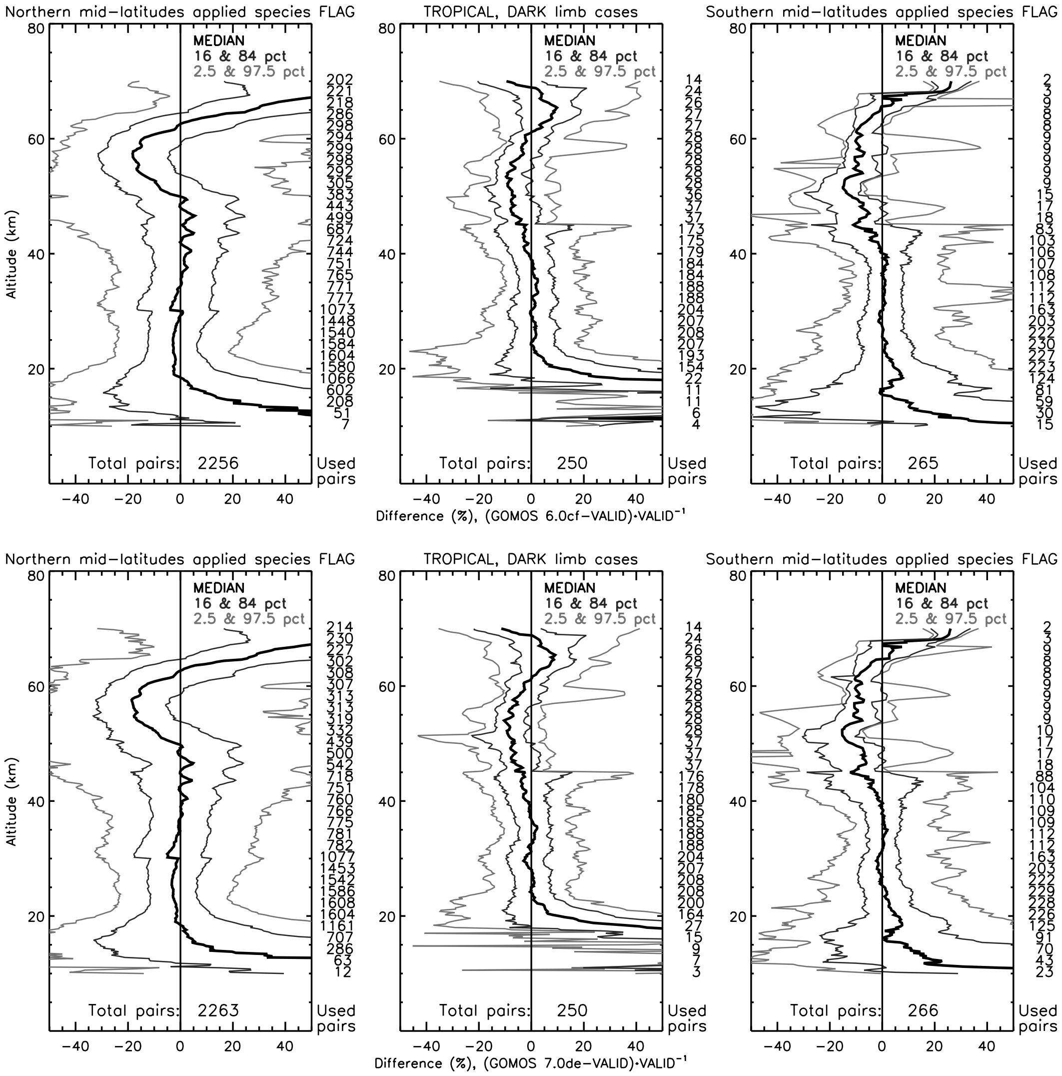


Figure 5. Percentile difference plots for version 6.0cf (top) and 7.0de (bottom), both having GOMOS data limited to 30 % max. error. Left panel showing Northern mid-latitudes, middle panel showing the tropics and right panel showing the Southern mid-latitudes.

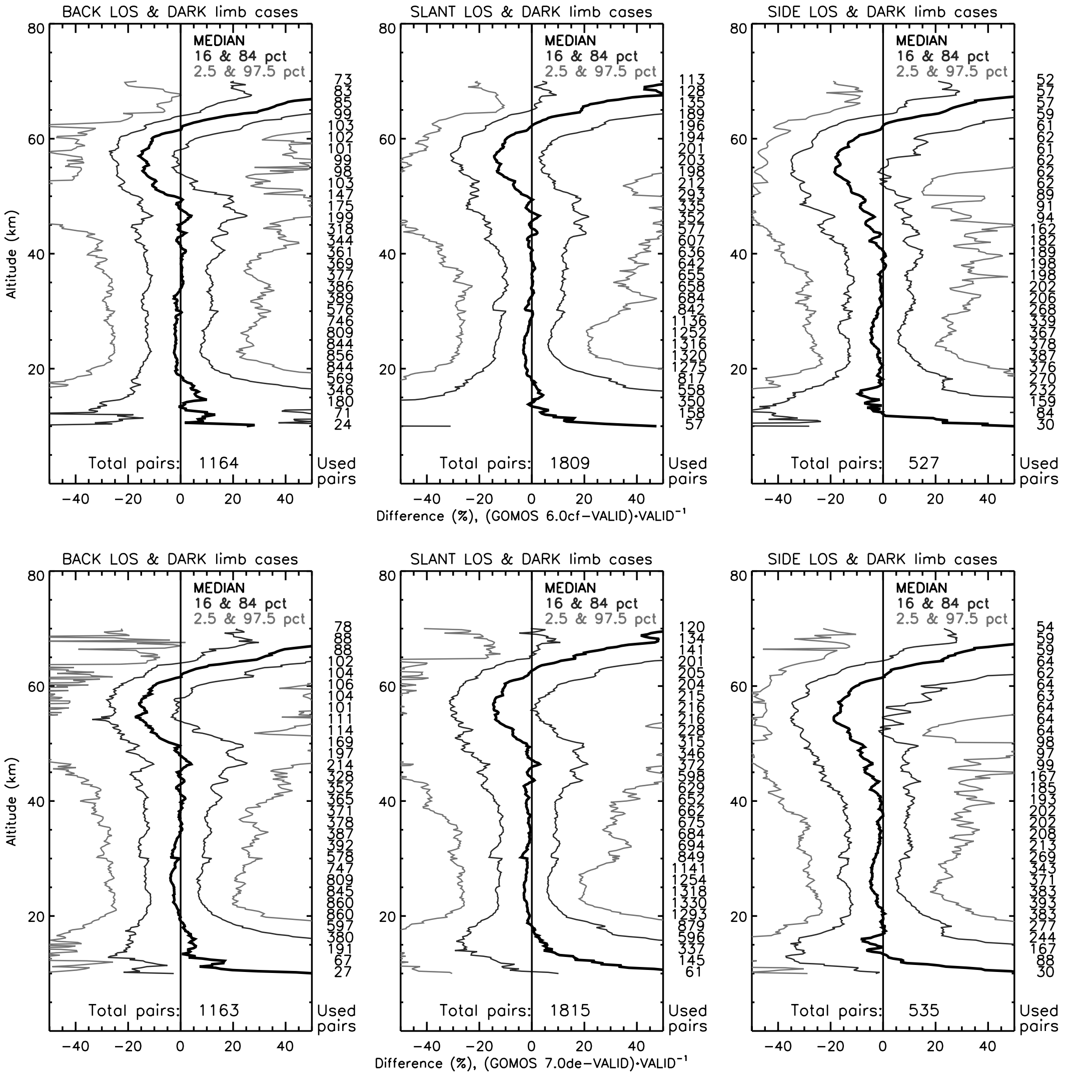


Figure 6. Percentile difference plots for version 6.0cf (top) and 7.0de (bottom), both having GOMOS data limited to 30% max. error. Left panel showing Backwards viewing (azimuth angles ranging between -10° and 10°), middle panel showing the results for profiles obtained in the slant line of sight (angles between 10° and 45°) and right panel showing the results for the side-ward looking observations (angles between 45° and 90°).

Figure 3, Figure 5 and Figure 6 show that if the datasets are sufficiently large, both versions (6.0cf and 7.0de) behave similarly except for a few outlier profiles.

Differences with the ground-based/balloon-borne measurements are therefore as reported for GOPR version 6.0cf: overall GOMOS measurements in dark limb match the validation instruments within a few percent between 20 and 50 km. In the polar region we can observe the strongest deviations (up to a negative bias of 20%), but most of these observations are flagged as twilight and/or straylight contaminated and this region also has a high spatial variability. Too few data are available to indicate if the light contamination affects the validation results significantly. In the tropics, deviation from the 0-difference line starts higher down into the atmosphere (seen from above). No effect seems to be introduced by the instrument line of sight.

Conclusions

GOPR versions 6.0cf and 7.0de compare similarly to the ground-based data, with differences mainly visible in outlier profiles. Both versions therefore match the lidar, sonde and microwave radiometer data within a few percent between 20 and 50 km. The largest deviations (up to 20%) occur in the polar region. Most of these observations are flagged as twilight and/or straylight contaminated profiles, however, and a large spatial heterogeneity exists in this area. Too few data are available to see which variable affect the results most. Increasing the error limit from 30% to 100% is sometimes beneficial (through increase of number of available profiles) and other times disadvantageous (through the inclusion of outlier profiles).