# COMPARISONS AND VALIDATION FO SCIAMACHY O3 AND NO2 PROFILES FROM OL3.0 AND IUP/IFE RETRIEVAL WITH ACE-FTS, GOMOS; HALOE, MIPAS, POAM III AND SAGE II

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## ABSTRACT

The newest operational version OL3.0 and the scientific products from IUP/IFE of ozone and NO2 profiles from (SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY) (SCIAMACHY) on ENVISAT are validated by comparisons with the data products of the space borne sensors Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE FTS, v2.2update), Halogen Occultation Experiment (HALOE, v19), Polar Ozone and Aerosol Measurement III (POAM III, v4) and Stratospheric Aerosol and Gas Experiment II (SAGE II, v6.2) in order to assess the level-2 data retrieval accuracy of these selected trace gas products. In addition also cross comparisons were made to the two other atmospheric ENVISAT instruments GOMOS and MIPAS. Validation results are quite preliminary. There is an indication that OL3.0 data products show a major improvement compared to previous operational data versions: still the ozone profiles show an obvious negative offset of up to 15% between 17.5 and 38.5 km (RMS <20%), a high negative bias around 40 km and even larger biases in the arctic regions. Results are consistent among the different satellite comparisons and the triple comparisons including SCIAMACHY data, independent satellite data and ground based lidar measurements. These biases have been discussed to be partly explained by choosing the reference height of 42 km in the retrieval, which also becomes more expressed at high solar zenith angle (SZA), as it is the case for the arctic comparisons. An update of the retrieval will focus on choosing a more appropriate reference height. Operational NO2 profiles show a constant positive bias of up to 25% (RMS < 30%) between 25 and 42.5 km as compared to HALOE, below 25 km HALOE NO2 are known to bear a negative bias. For all comparisons it is not clear from these comparisons if there is a remaining tangent height offset in the lv-1 v6.02 product used in the processing of SCIA OL3.0 and IUP limb retrievals. There is a slight indications that in the tropics the SCIAMACHY tangent height are still on average 500 m to high and maybe around 1 km too low in the arctic.

## 1 INTRODUCTION

Recently a validation reference set of the new operational SCIAMACHY limb ozone and NO2 profiles version OL3.0 was released. In order to assess the quality of this data set and give recommendations for reprocessing, comparisons to the scientific SCIAMACHY algorithms from the IUP, but also to independent solar occultation data sets of the well validated long term data sets of satellite sensors HALOE, SAGE II and POAM III and the new sensor ACE-FTS were done. Also comparisons to GOMS and MIPAS were performed. Results are shown in the following chapters.

## 2 DATA PRODUCTS USED IN COMPARISONS

### 2.1 SCIAMACHY operational product v3.0

We used the recently released operational data version OL3.0 which is based on the v6.02 SCIAMACHY level-1 data and are described in von Bargen (this issue). This level-1 data set is tangent height corrected by subtracting generally 1 km from the tangent height and including the attitude correction.

### 2.2 IUP SCIAMACHY limb profiles

IUP $O_3$ profiles from SCIAMACHY limb measurements used in this study are retrieved from all available Level-0 data by the method described in von Savigny et al. (2005) and are from data version 1.63. The retrieval uses three wavelengths (525 nm, 600 nm and 675 nm) in the $O_3$ Chappuis band and a non-linear, iterative optimal estimation approach together with radiative transfer model (RTM) calculations from SCIARAYS (Kaiser, 2001). The previous SCIA-MACHY IUP ozone profile version 1.62 has been validated intensively with lidar, sondes, microwave, and SAGE II and III data (see Brinksma et al. 2006), results show SCIA-IUP v1.62 is at 16 to 40 km biased low by a few percent (3-6%, RMS 10%).

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IUP $NO_2$ profiles from SCIAMACHY limb measurements used in this study are retrieved from all available Level-1 Version 3 (a previous version is described in Rozanov et al. 2005a). The retrieval uses the spectral window between 420 and 490 nm and a ratio of limb measurements with limb data at 40 km tangent height as reference. The vertical profile is retrieved using an optimal estimation approach and weighting functions from the RTM SCIATRAN (Rozanov et al., 2005b). A pre-fit routine is applied to improve the radiometric calibration. Comparisons of SCIAMACHY-IUP $NO_2$ profiles with HALOE measurements, which were scaled to the SZA of the SCIAMACHY measurements using a 2D chemical transport model calculation, showed an agreement to within 15% (RMS 10-30%) between 22 and 33 km altitude (Bracher et al., 2005).

In all comparisons shown in this paper, except the ones in the comparisons to ACE-FTS, the SCIAMACHY IUP profiles are based on the new level-1 data set 6.02. For the comparisons to ACE_FTS were no collocations have been found for the reference data set, v1.63 has been processed for several months in 2004 (Feb-Jun and Sep) based on v5.04 lv-1 data with the TRUE tangent height correction described in Kaiser et al. (2004).

### 2.3 Independent satellite sensors

Comparisons of SCIAMACHY ozone profiles have been done to HALOE v19, SAGE II v6.02, POAM v4.0, ACE-FTS v2.2update, GOMOS IPF v5.00 and MIPAS full resolution v4.61. The accuracy of HALOE v19 is based on validation results from Brühl et al. (1996) and given with 6% between 30 and 60 km and 12% between 15 and 30 km. SAGE II previous version accuracy was characterized by 5% from the tropopause up to 50 km (Wang et al. 2002, Cunnold et al. 1989). POAM v3 accuracy is given in Lumpe et al. (2002) with 5 to 10% between 13 and 60 km. ACE-FTS collects data since beginning of 2002 and recent validation results of ACE-FTS ozone profiles compared to microwave, balloon measurements (SPIRALE), MLS and SAGE III showed an agreement within 10% at 18 to 44 km.

Only comparisons with NO2 profiles for validation from HALOE v19 are presented in this study which showed in validation studies an agreement within 10 to 15% between 25 and 40 km. Below 25 km a negative bias was encountered (Gordley et al. 1996).

## 3 COMPARISONS OF SCIAMACHY OL3.0 AND SCIAMACHY IUP OZONE PROFILES WITH INDEPENDENT SATELLITE DATA AND TRIPLE COMPARISONS INCLUDING GROUNDBASED MEASUREMENTS

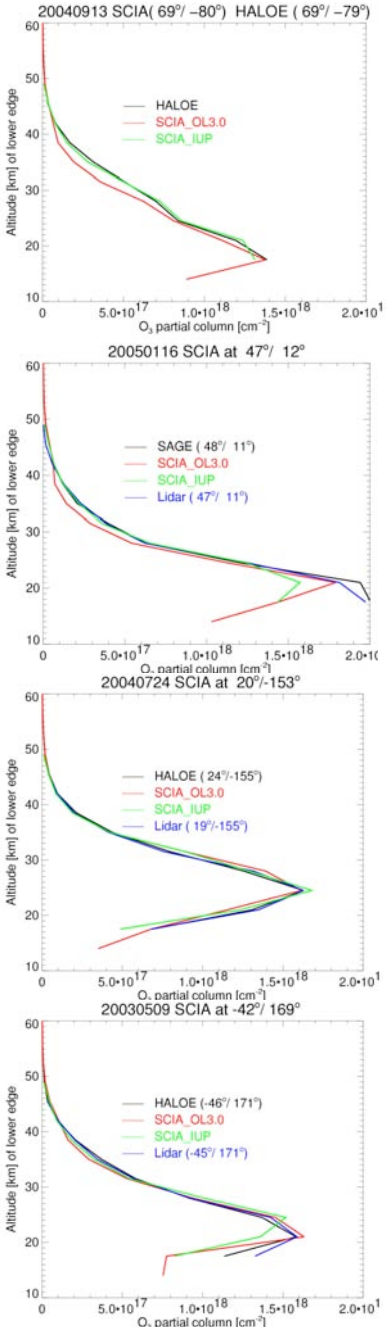
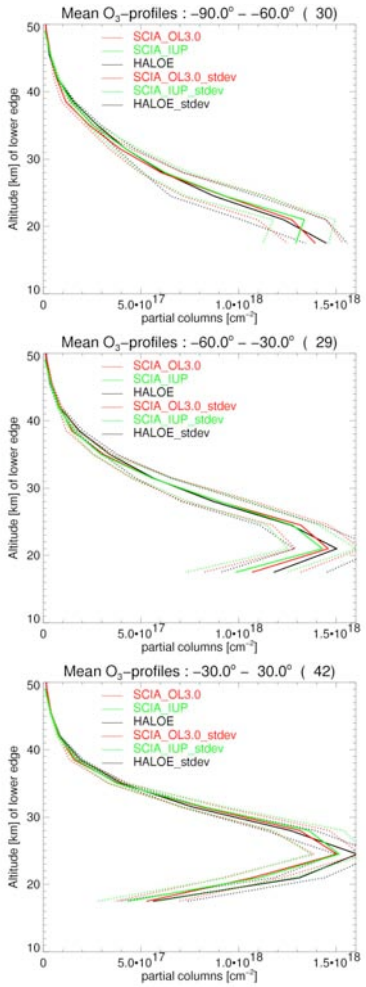



*Fig. 1. Examples of comparisons of collocated SCIAMACHY ozone profiles, from the operational OL3.0 product red), and IUP v1.63 (red) to ground based data (blue) and independent satellite measurements (black).*

For all comparisons to independent satellite data the collocation criteria of measurements taken within 500 km and 12 hrs of the SCIAMACHY measurement were applied. For comparisons to HALOE 143 collocations have been found, to SAGE II 14, to POAM III 23, to GOMOS 101 and to MIPAS v4.61 200. In addition for 14 collocations to HALOE and SAGE II also comparisons to lidar ground based measurements were found. Examples of the comparisons are shown in Fig. 1 and the results of the statistical analysis in Fig. 2.

The statistical analysis of all comparisons show differences among regions and correlated with that with solar zenith angle, but no differences with seasons and the time of year are seen in this small data set. It is not clear if there still remains a tangent height offset.



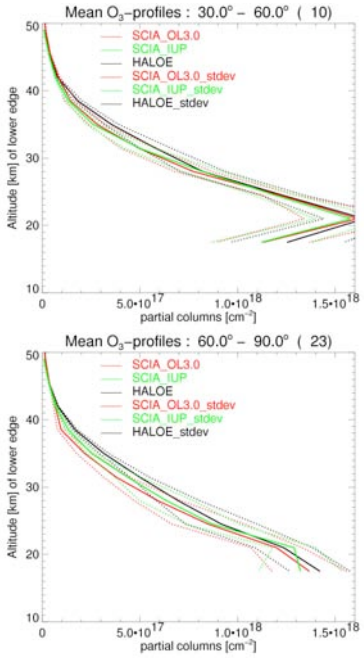




*Fig. 2. Mean profiles of the comparison of SCIAMACHY (red for OL3.0, green for IUP v.1.63) to HALOE (black) in different regions.*

One could state that there is an offset between 0.5 and 1 km in the Arctic with SCIAMACHY profiles tangent heights being to low and 0.5 km in the tropics with SCIAMACHY being to high. Agreement is best in the tropics and worst in the polar regions (especially Arctic, SZA >70°). Overall, SCIAMACHY profiles for both retrievals (see Fig. 3) tend to be too low between 17.5 and 38.5 km, especially at the ozone maximum with up to 15%. SCIAMACHY OL3.0 show a large negative peak consistently at all comparisons around 40 km, probably caused by the chosen reference tangent height chosen at 42 km. This is not seen in the IUP product. Comparisons to GOMOS, MIPAS and POAM are in line with those findings.

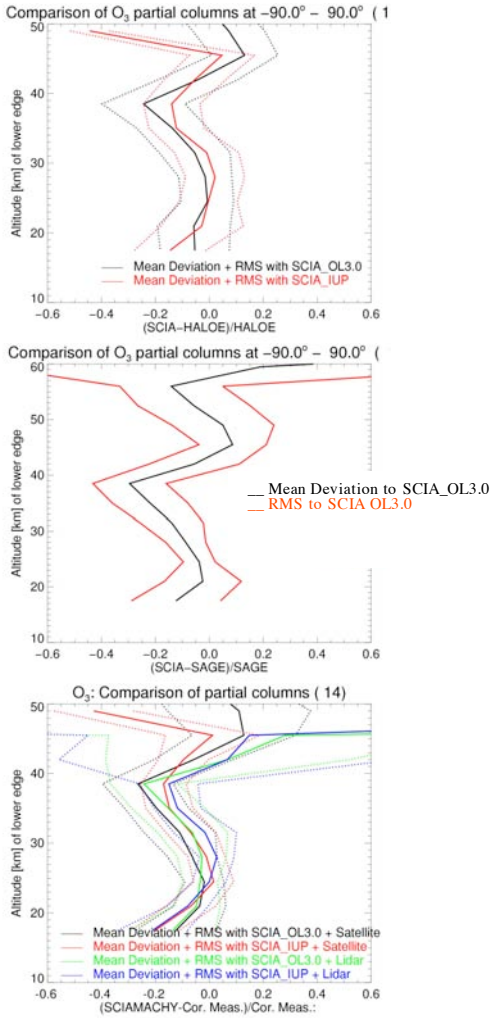



*Fig. 3. Mean relative deviation and RMS of mean relative deviation SCIAMACHY (OL3.0 and IUP v.1.63) to HALOE (upper panel), SAGE II (middle panel) and triple comparisons.*

## 4 COMPARISONS OF OZONE PROFILES FROM SCIAMACHY IUP V1.63 TO ACE-FTS 2.2 UPDATE

ACE-FTS data are only available from February 2004. We could only find 3 collocations with the SCIAMACHY validation reference set, therefore we compared ACE-FTS data to SCIAMACHY v1.63 from Feb-June 2004 and Sep 2004 to ACE-FTS. All in all we found 331 collocations within 250 km and 12 hrs. 80% of the measurements were in the arctic (and 90% out of these at 70° to 80° SZA). The remaining collocations were with 10 to 20 collocations evenly distributed to the other regions. Statistical results are shown in Figs. 4 and 5.

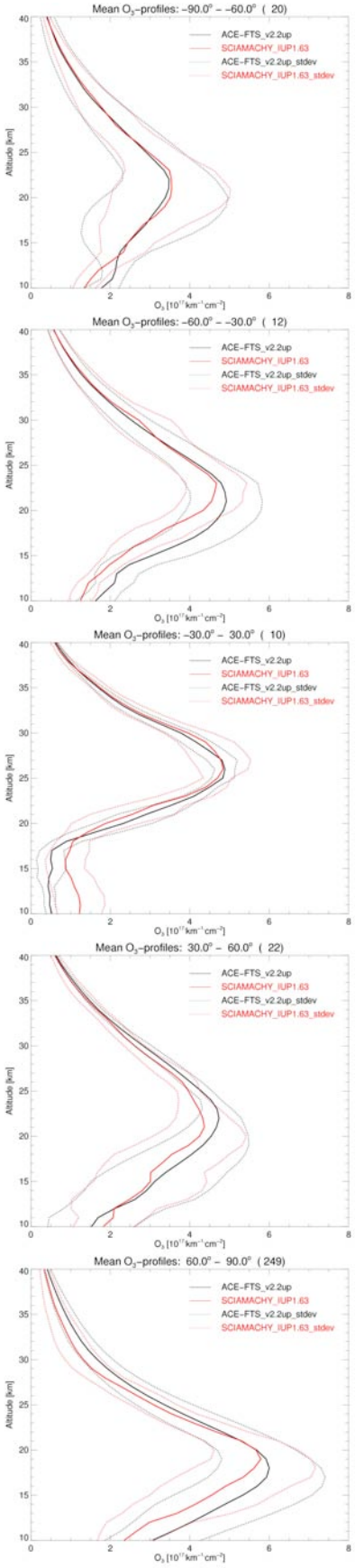



*Fig. 4. Mean profiles of comparison of collocated $O_3$ profiles from SCIAMACHY-IUP v1.63 based on SCIA lv-1 v6.02 and ACE-FTS v2.2update in dependence to latitude.*

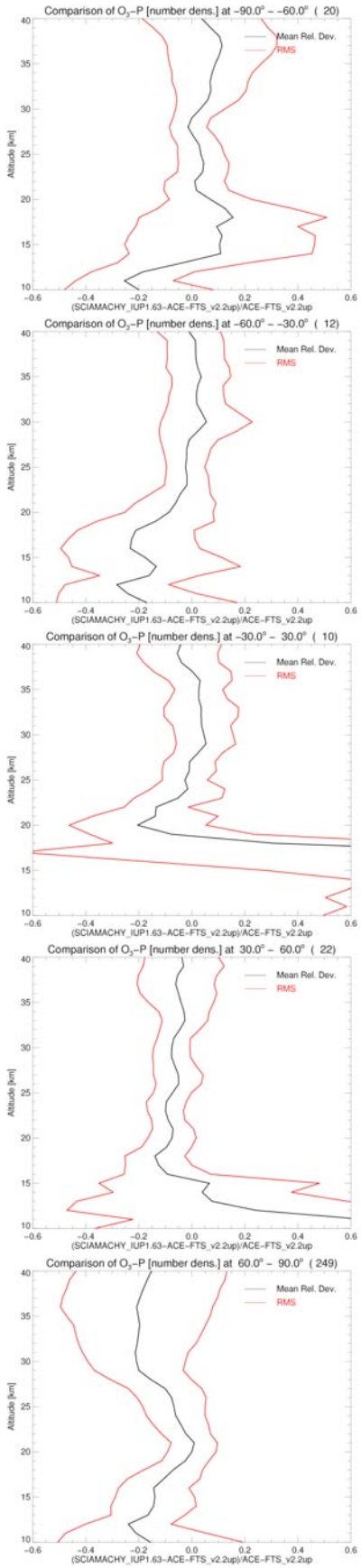



*Fig. 5. Mean relative deviation and RMS of mean relative deviation profiles of comparison of collocated $O_3$ profiles from SCIAMACHY-IUP v1.63 based on SCIA lv-1 v5.04 and ACE-FTS v2.2update in dependence to latitude.*

The statistical analysis of all comparisons show differences among regions and correlated with that with solar zenith angle, but no differences with seasons and the time of year are seen. Besides the Arctic SCIA ACMYH IUP v1.63 agrees within 10% (RMS <20%) of ACE-FTS, in the Arctic SCIAMACHY is biased low by up to 22 km. The agreement is therefore better than for the validation reference set comparisons.

There seems a slight remaining tangent height offset with SCIAMACHY IUP TH to high by 0.5 km in the tropics and southern hemispheric mid latitudes and by 1 km in the Arctic.

## 5 COMPARISONS OF SCIAMACHY OL3.0 AND SCIAMACHY IUP NO2 PROFILES WITH HALOE

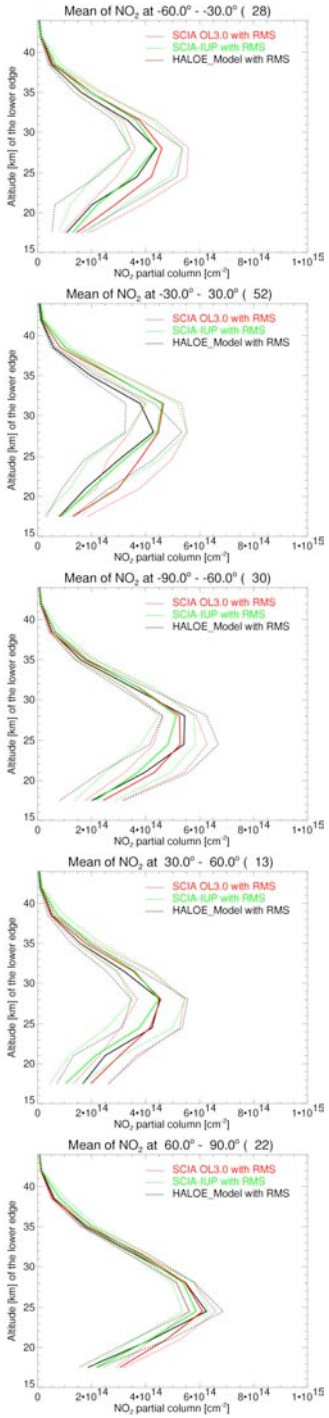



*Fig. 6. Mean profiles of comparison of collocated $NO_2$ profiles from SCIAMACHY OL3.0 and IUP v1.63 based on SCIA lv-1 v6.02 and HALOE v19 scaled to SCIAMACHY SZA.*

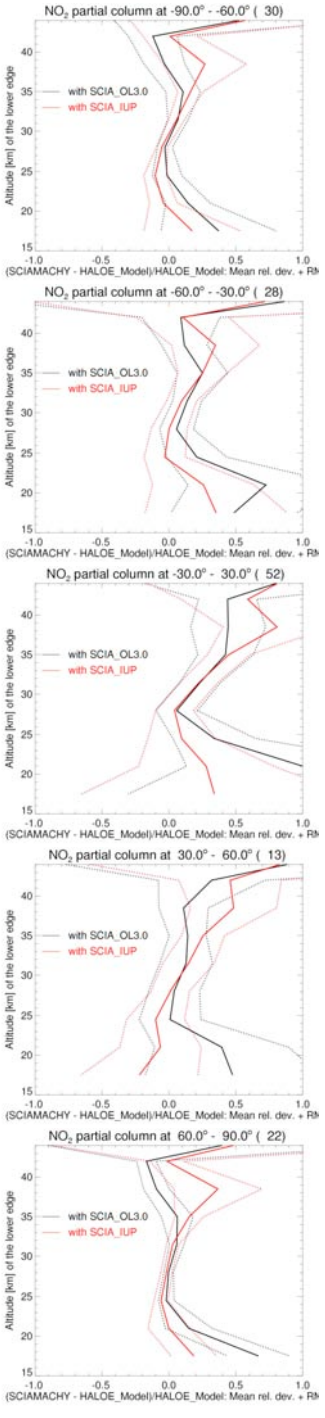



*Fig. 7. Mean relative deviation and RMS of mean relative deviation profiles of comparison of collocated $NO_2$ profiles from SCIAMACHY OL3.0 and IUP v1.63 based on SCIA lv-1 v6.02 and HALOE v19 scaled to SCIAMCHY SZA.*

For all comparisons to independent satellite data the collocation criteria of measurements taken within 500 km and 12 hrs of the SCIAMACHY measurement were applied. The HALOE NO2 profiles taken in solar occultation at 90° were photochemically corrected by scaling them to the SCIAMACHY SZA according to the method developed in Bracher et al. (2005).

Statistical results are shown in Fig. 6 and 7. All in all for comparisons to HALOE 145 collocations have been found, with a general good agreement and no apparent tangent height shift and unclear dependences to season and year of sampling. Still overall SCIAMACHY NO2 profiles show a high bias at 25 to 42 km with 3 to 24% for SCIA OL3.0, especially above and below the NO2 maximum. SCIA IUP is closer to HALOE up to 35 km but shows above a much higher positive bias than SCIA OL3.0. For both SCIAMACHY retrievals results agree best in polar regions and worst in the tropics.

## 7 ACKNOWLEDGEMENTS

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