1st Final Report in Phase A for ESRIN contract No. 18809/05-I-LG

"Long term validation of SCIAMACHY Data" (SciLoV)

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AUTHORS: DR. ASTRID BRACHER, DR. MARK WEBER, DR. HEINRICH BOVENSMANN, DR. STEFAN NOEL, DR. CHRISTIAN VON SAVIGNY, KATRIN HOEEPNER*, PROF. DR. JOHN BURROWS

Institute of Environmental Physics (IUP-HB), University of Bremen, POB 330440, D-28334-Bremen, Germany, Email: bracher@uni-bremen.de
*DLR Oberpfaffenhofen, Wessling, Germany

INTRODUCTION:

The Phase A of the project started with the kickoff meeting which was held at 21 Feb 2005 as a telephone conference on with Dr. Mark Weber (IUP-HB), Dr. Astrid Bracher (IUP-HB) and Claus Zehner (ESRIN) - see details in the minutes. In Phase A of this project we fulfilled all work packages within the scope of availability and quality of the operational SCIAMACHY data (see Table 1) that were released within this project schedule:

- The validation (WP 110) and the verification (WP 210) of SCIAMACHY operational ozone columns were done for the most recent consolidated data versions 5.01/5.04 which have been already released in 2004 (differences are negligible between both versions with regard to total ozone). In Dec 2005 nadir level-2 and level-1 data prototype version 6.0 were released for a small subset of SCIAMACHY measurements by DLR where we participated in the verification of these data (validation was covered by M. van Roozendael et al., BIRA).
- The validation (WP 120), verification (WP 220), and comparisons to measurements of the two other atmospheric ENVISAT sensors GOMOS and MIPAS (WP 400) of ozone and NO2 (only for WP 220, WP 430) profiles from SCIAMACHY operational data were done for the prototype limb data versions 2.4, 2.5, 2.8, 5.04 (in our plots named 3.0) and 6.0A (an intermediate test version of v6.0). Also for WP 120 and WP 220 we did an extensive global validation and verification of the larger available operational data set v2.4 and 2.5. In WP 400 cross comparisons of MIPAS and GOMOS to the newer SCIAMACHY v2.8, 5.04 and 6.0A and to SCIAMACHY-IUP retrievals were carried out. A list of the different subsets of SCIAMACHY operational limb data provided by DLR to the verification and validation teams within Phase A of this project is given in Table 1.
- For WP130 the effect of improving the absolute radiometric calibration by generating new radiometric key data on SCIAMACHY irradiance data was studied and tested by validation with different satellite spectra and to a spectrum used in the atmospheric radiative transfer model MODTRAN 3.7. In addition, the monitoring of the SCIAMACHY instrument performance using solar irradiance measurements has been significantly expanded.
- For WP 500, a subcontract between the Institute of Environmental Physics (IUP/IFE) at University of Bremen and the Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR) was agreed upon in July 2005. As part of this contract DLR was paid a total of 5000 Euro in order to provide Polarstern ship data of mesospheric temperatures (WP 520 "Latitudinal OH-Mesopause temperature data set"). This data was used for the validation of SCIAMACHY OH-mesopause temperatures retrieved at the Institute of Environmental Physics (WP 510, 530).

Table 1: List of different subsets of operational SCIAMACHY ozone and NO_2 profiles which have been released from the DLR SCIAMACHY data processing team to our verification and validation teams with data version, date of release, and time frame and coverage.

Data Version	Date of Release	Time Frame and Coverage of Subset
v2.1	April 2004	some states from Jul to Dec 2002
v2.4	February 2005	entire data set from 20 Sep 2004 to 27 Nov 2004
v2.5	February 2005	entire data set since 7 Dec 2004
v2.8	May 2005	12 orbits of 2004: 15 Jan, 20 Mar, 23 Jun, 20 Sep
5.04 (internal 3.0)	November 2005	same as v2.8
v6.0A (prelim.)	February 2006	8 orbits of 2003, 4 orbits out of the 12 orbits from v2.8

We participated and presented our results from WP 100 and WP 200 in all SCIAMACHY Verification Meetings and SADDU Meetings held during Phase A and also discussed our results at the SSAG Meeting and SCIAVALIG meetings in Oct 2005. We contributed to the new SCIAMACHY reference set in accordance to our collocated measurements used for validating SCIAMACHY ozone columns and profiles and send our requests to Ankie Piters, KNMI, the coordinator of SCIAVALIG. In addition, some results of WP 100, WP200 and WP 400 have been presented at the AURA Science Meeting, at the SACADA final meeting and are published in peer-reviewed papers. Lists of meetings participated, co-operations with other research groups and publications arisen from this project are given at the end of this report.

DESCRIPTION OF WORK PERFORMED:

The following chapters will describe in more detail the work performed in each work package, but it focuses on newer results obtained in the second half of Phase A and only briefly refer to results from the first half of the project which were described in detail in our 1st Progress Report of Phase A of SciLoV.

Task 1 – Long Term Validation

WP 110 – Validation of SCIAMACHY ozone columns (Astrid Bracher)

In WP 110 we validated the recent consolidated SCIAMACHY data version 5.01/5.04 with GOME WFDOAS total ozone data. Some preliminary comparisons to total ozone data from SCIAMACHY WFDOAS and OMI TOMS algorithm were performed. Results of the comparisons of SCIAMACHY O3 columns v5.01/5.04 from January to July 2003 with GOME WFDOAS and SCIAMACHY WFDOAS have been published in Bracher et al. (2005d). Results of these satellite comparisons show that SCIAMACHY total O_3 v5.01/5.04 are on average 1% (±2%) lower than GOME WFDOAS and scatter increases at solar zenith angles above 85° and at very low total ozone values. We also found dependencies on solar zenith angle, latitudes, and total ozone amounts which are explained by the implementation of an outdated GOME algorithm based on GOME Data Processor (GDP) version 2.4 for the SCIAMACHY operational product. The reprocessing with an algorithm equivalent to GOME WFDOAS V1.0 shows that the offset and dependencies on solar zenith angle, latitude, and total ozone disappear and that SCIAMACHY WFDOAS data are within 1% of GOME WFDOAS. Results of the preliminary comparisons of SCIAMACHY WFDOAS, SCIAMACHY v5.04, GOME WFDOAS and OMI TOMS algorithm from 11 Sep 2004 have been presented at the AURA Science Meeting in Nov 2005 and are shown in Fig. 1. These comparisons at one day show clearly that ozone columns from SCIAMACHY WFDOAS and OMI TOMS agree within 3% with the tendency of OMI columns being on average 2% lower than SCIA WFDOAS. Deviations between SCIA v5.04 and OMI are much larger (up to 20%). Comparisons to GOME WFDOAS are consistent with comparisons to OMI. As already stated in the first progress report and at various meetings we expect that comparisons to the soon released SCIAMACHY operational ozone columns based on GDP 4.0 will be much superior compared to SCIA 5.04 and deviations are expected to be in the same order as for comparisons to SCIA WFDOAS. As soon as we get the new operational data set extensive comparisons to OMI, GOME WFDOAS (and SCIAMACHY WFDOAS for WP 210) will be executed. One has to keep in mind that the first SCIAMACHY WFDOAS version used for these comparisons used the GOME FM cross-sections (Burrows et al. 1999) and the GOME Ring database (Coldewey-Egbers et al. 2005). Further updates of SCIAMACHY WFDOAS are summarised in WP 210.

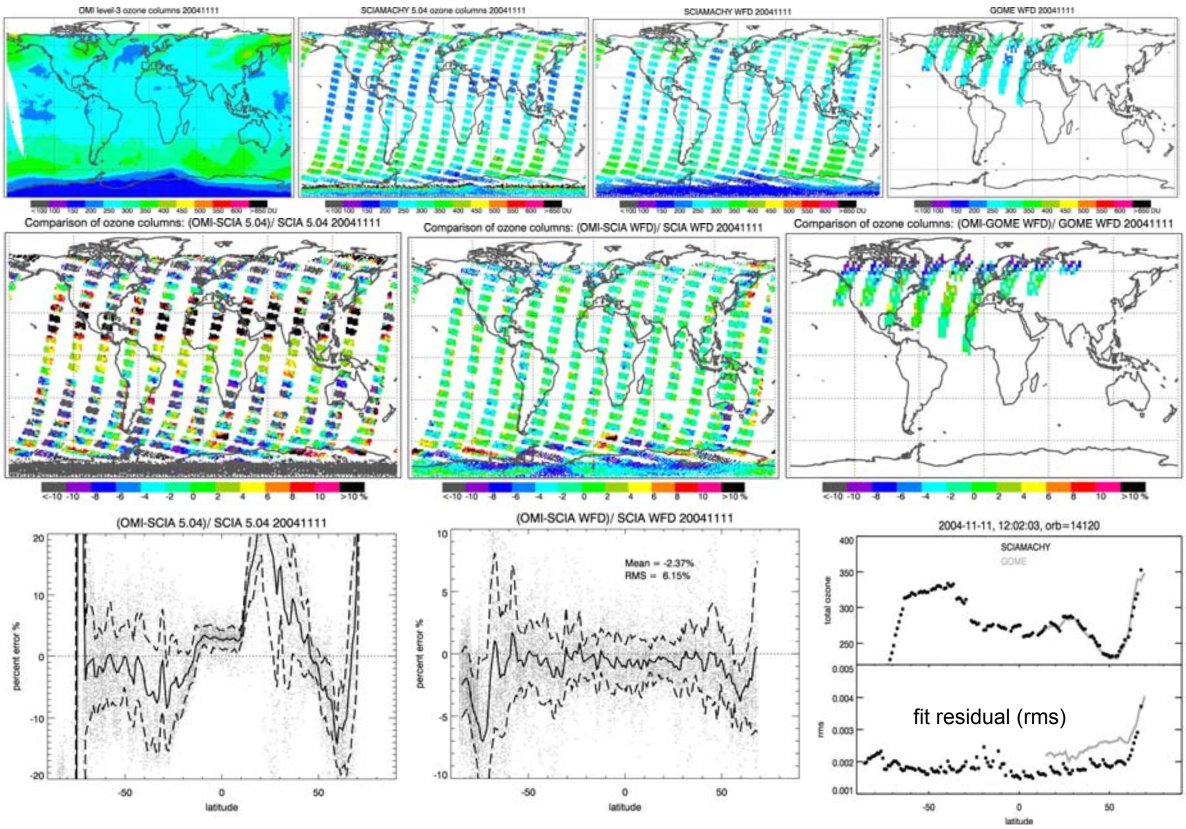

Fig. 1. Comparisons of total ozone datasets binned into 1.0° x 1.25° grids from OMI TOMS algorithm (level-3 data set, upper left panel), SCIAMACHY V5.04 with (upper second left panel), SCIAMACHY WFDOAS V1.0 (upper second right panel) and GOME WFDOAS V1.0 (upper right panel) from 11 Sep 2004. The middle panel shows the mean relative deviations of the comparisons of binned OMI to binned SCIAMACHY 5.04 (left) and SCIAMACHY WFDOAS (right). The lower panel shows as a function of latitude the mean relative deviations (black dots), mean values of mean relative deviations (straight line) and root mean squares of the mean relative deviation (dotted line) of the comparisons of binned OMI and SCIAMACHY data with left for comparisons to SCIAMACHY 5.04 and right to SCIAMACHY WFDOAS.

WP 120 - Validation of SCIAMACHY ozone profiles (Astrid Bracher, Klaus Bramstedt)

Within this work package global stratospheric ozone measured in limb by SCIAMACHY from the operational product are supposed to be compared to collocated data from SBUV-2, OMI, HALOE and SAGE II. As pointed out above, the global operational data set of SCIAMACHY limb ozone profiles is limited to data versions 2.4 (covering Sep-Nov 2004) and 2.5 (since Dec 2004). Our extensive validation in early 2005 of the v2.4/2.5 ozone profile data set with SAGE II, now published in the paper by Brinksma et al. (2006) and already reported in the first progress report, showed that these data are not well suited for further comparisons: more than 20% of the SCIAMACHY data v2.4 and 2.5 showed unrealistic ozone values (most of them are north of 15°S) and the remaining data still suffer from an incorrect tangent height (this problem is well documented in von Savigny et al. 2005a). Even when these v2.4 and 2.5 data were compared to SAGE II after a downward shift of the tangent height of 1.5 km, ozone profiles of v2.4 are within –20 to +13% (RMS 8 to 23%) and of v2.5 slightly improved with –20 to +10% (RMS 9 to 18%). One has to say that compared to the first operational SCIAMACHY ozone profiles (v2.1) released in April 2004 (see Brinksma et al. 2004) the v2.4 and 2.5 are no improvement (Table 2). Therefore we concentrated our validation efforts on the subsets of subsequent data versions released by the

DLR SCIAMACHY data processing team to us in 2005/2006 (see summary in Table 1). Since these data sets are quite limited to a few measurements (8 to 12 orbits), we used so far only comparisons to HALOE v19 on UARS and SAGE II v6.2 on ERBS which are both well validated and have vertical resolutions similar to SCIAMACHY limb observations At this stage these comparisons are much more valuable than comparisons to SBUV-2 and OMI (anyway so far no OMI ozone profiles are available) which have a much coarser vertical resolution. All results from the validation of the various SCIAMACHY operational data versions are summarised in Table 2 and were presented at the various Verification Meetings in June 2005, Dec 2005, Feb 2006 and at the SADDU Meeting in Feb 2005 (see Bracher and Bramstedt 2005a, 2005b, 2006, Bracher et al. 2005c).

Table 2: Statistical results for the different versions of operational SCIAMACHY ozone profiles, which have been released from the DLR SCIAMACHY data processing team to us, compared to HALOE v19 and SAGE II v6.2 with mean relative deviation (mrd), RMS of mean relative deviation (RMS), altitude level (alt [km]) and number of collocations (n); "+th" signifies that a tangent height shift according to Kaiser et al. (2005) was applied; "-1.5" signifies that a tangent height shift of –1.5 km was applied

Version	alt [km]	mrd-HALOE	RMS-HALOE	n-HALOE	mrd-SAGE	RMS-SAGE	n-SAGE
v2.1	21-41	-8 to +20 %	20%	43	+3 to 17%	20-25%	44
v2.4-1.5	21-41				-20 to +13%	8-23%	350
v2.5-1.5	21-41				-20 to +10%	9-18%	285
v2.8	22-35	-13 to +18%	7-32%	9	(for both HALOE and SAGE)		
v2.8+th	22-35	-10 to +4%	5-15%	9	(for both HALOE and SAGE)		
v5.04	22-41	-4 to +7%	11-21%	13	(for both HALOE and SAGE)		
v6.0A	22-41	-3 to +7%	10-30%	13	(for both HALOE and SAGE)		

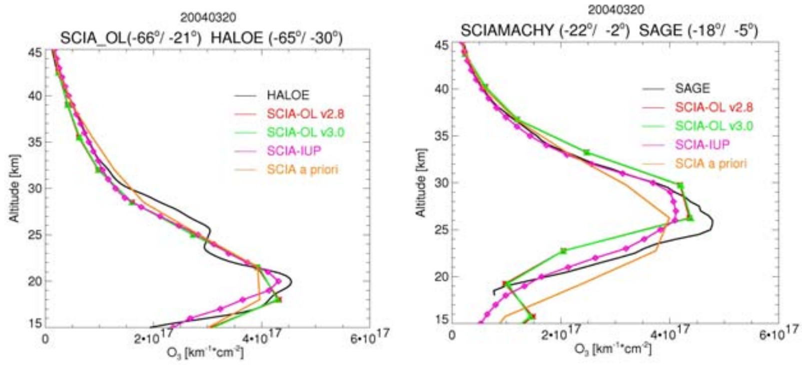

Fig. 2: Examples of collocated SCIAMACHY ozone profiles from the IUP retrieval v1.63 and by the offline versions 2.8 and 5.04 (named in the plot 3.0) and HALOE v19 (left) and SAGE II v4.62 (right) ozone profiles

Table 2 summarizes the statistical results for all SCIAMACHY offline ozone profile comparisons to HALOE and SAGE II. Fig. 2 illustrates the comparison of v2.8 and 5.04 (here named 3.0) for some collocations with HALOE and SAGE II. It shows that both versions are almost identical. This has been also found for the other comparisons to HALOE and SAGE II (results not shown), and to MIPAS and GOMOS (see WP 410, WP 420). In addition to that, just now (7 Feb 2006) we start to validate selected orbits of test version 6.0A which is based on the new level-1 data v6.0. Similar results as with v5.04 were obtained. Since the number of matches are increased for v5.04 and 6.0A, the statistics improve for these SCIAMACHY versions upon v2.8.We expect very good results for the new L2 IPF version 6.0 where the tangent height problem is minimised by using a new attitude files (AUX-FRA) accounting for the large variations in spacecraft pitch axis before Dec. 2003 and by applying an additional constant effective tangent height shift of about 1 km. This version 6.0 is currently under verification and results can be expected by the end of Feb 2006.

WP 130 Validation of SCIAMACHY irradiance (Jochen Skupin, Stefan Noel)

Table 3: Mean differences (per channel) between SCIAMACHY and other data in percent.

	SCIAMACHY channels (in plots marked by vertical dashed lines)							
	1	2	3	4	5	6	7	8
	Wavelength ranges in nm							
Difference with	240-314	309-405	394-620	604-805	785-1050	1000-1750	1940-2040	2265-2380
Kurucz	0.62	-1.16	-0.18	0.82	1.96	-0.04	-0.27	2.87
SIM	+11.95	-1.09	-1.30	+2.60	+5.44	+4.25	-	-
SOLSPEC	4.2	-2.73	0.	1.25	4.28	0.11	-3.27	0.02
SOLSTICE	0.8	-1.42	-	-	-	-	-	-
SUSIM	3.49	-0.42		-	-	-	-	-

Within this work package the effect of improving the absolute radiometric calibration by generating new radiometric key data (Noel 2005) on SCIAMACHY irradiance data was studied. The new key data should remove the 10-15% irradiance bias observed before. The new SCIAMACHY irradiances are as expected except for a deviation in channel 6 which indicates an (at least) incomplete implementation of the PET correction for channels 6 to 8 (PCR 34). The absolute radiometric calibrated SCIAMACHY solar spectrum presented here is based on these correction factors and it is a preliminary scientific product. It is not (yet) part of the official SCIAMACHY data products distributed by ESA. These spectra were compared with results from other data sources such as SIM, SOLSPEC, SOLSTICE and SUSIM. To take care of the different spectral resolutions of the instruments, high-resolution data are adapted to the lower resolution of the data they are compared with, i.e. the Kurucz spectrum as used in the atmospheric radiative transfer model MODTRAN 3.7 (Kurucz et al.1995) is convoluted with the SCIAMACHY slit function to match SCIAMACHY spectral resolution. On the other hand, SCIAMACHY solar irradiance is re-binned to match the spectral resolution of SIM (Harder et al., 2000), SOLSPEC (Thuillier et al., 2003), SOLSTICE (Rottmann and Woods, 1994), and SUSIM (Floyd et al. 2003). For the latter two UARS instruments, data are only available for wavelengths up to 420 nm at a spectral resolution of 1 nm. At low spectral resolution the UV Fraunhofer structures are smoothed out and generally better agreement is achieved as with higher resolution data from SIM, SOLSPEC and Kurucz. The comparisons are shown in Figs. 2 to 4 of the first progress report and the mean differences (per channel) between SCIAMACHY and other data sources are given in Table 3. Results are published in Skupin et al. (2005). SCIAMACHY is in agreement with Kurucz solar spectrum over the entire wavelength range from 240 to 2380 nm to within 3%. The same can be concluded from the comparison with other data for channels 2 to 4 (309-805 nm) and for channel 8. All other channels agree to within 6% except for channel 1 where SCIAMACHY is almost 12% higher than SIM.

The verification of the new Version 6 of the operational SCIAMACHY Level 0-1 processor is still ongoing. This processor version will include new radiometric key data as mentioned above. Since the first progress report no new irradiance data products have been generated, therefore no

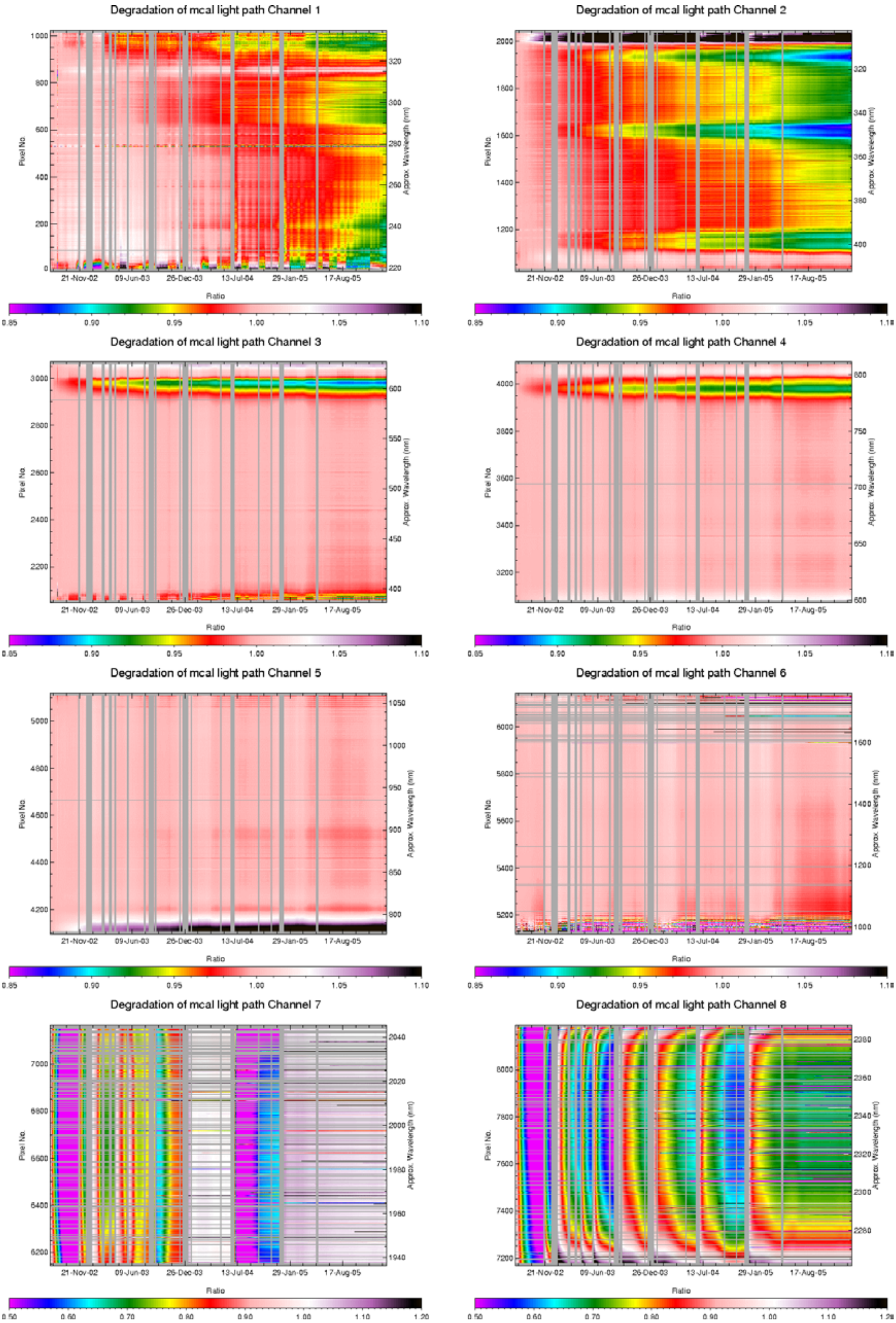

Fig. 3: Spectral light path monitoring results for the calibration light path. Note the different colour scales for channels 7 and 8.

additional irradiance validation activities have been performed. However, significant progress has been made in monitoring the SCIAMACHY instrument performance with time based upon solar irradiance measurements. The SOST-IFE web site (http://www.iup.physik.uni-bremen.de/sciamachy/LTM/LTM.html) now presents besides channel average light path monitoring results, regular updated plots of the spectral instrument throughput as a function of time. Furthermore, first results for the PMD degradation are shown on this web site as well. The spectral light path monitoring results are a first step towards continuous operational monitoring of calibration factors which will be fed directly into the operational data processing chain to correct for degradation. This will improve greatly the quality of all operational products, especially radiances and irradiances. Fig. 3 shows the spectral light path monitoring results for the so-called calibration light path derived from the observation of the unobscured sun via the ASM mirror and the ESM diffuser. Note that these are the same measurements from which the operational absolute calibrated solar irradiance spectra are derived. Fig. 3 shows very clearly the increasing degradation in the UV and the large throughput variations due to icing of the detectors in channels 7 and 8, whereas channels 3 to 6 remain remarkably stable. These effects have to be considered in the generation of a fully calibrated irradiance product. These monitoring results are also summarized in the ESA bi-monthly reports (see http://earth.esa.int/pcs/envisat/sciamachy/reports) where further details can be found.

Task 2 – Algorithm and Lv 2 Product Verification

WP 210 – Verification of operational nadir trace gas products (Mark Weber, Astrid Bracher, Lok Nath Lamsal, Andreas Richter, Heinrich Bovensmann)

Verification of ozone columns:

Within this work package we compared our in-house developed SCIAMACHY WFDOAS total ozone algorithm to total ozone from SCIAMACHY 5.01/5.04, GOME WFDOAS, OMI-TOMS algorithm, TOSOMI, and GDOAS_SCIA (SDOAS). The comparisons to the first three algorithms have already been reported and discussed in WP110 and parts of these comparisons have been published in Bracher et al. (2005d). For verification of the implementation of GDP 4.0 for SCIAMACHY level-2 nadir processing we participated in the verification of preliminary results from DLR and intercomparisons with the two other scientific total ozone products SDOAS from BIRA and TOSOMI from KNMI. These comparisons have been shown by van Roozendael (BIRA) at the Verification Meeting at DLR Oberpfaffenhofen on 14 Dec 2005. These comparisons showed that beside the specific algorithm certain settings influence non-trivially the results. Therefore, further investigations were carried out to implement a SCIAMACHY Ring database (based upon SCIAMACHY solar and cross-section data) and the effect from the use of SCIAMACHY FM cross-section (Bogumil et al. 2003) was carefully evaluated. As reported by Eskes et al. (2005) and Bracher et al. (2005b), the use of the SCIA FM cross-sections resulted in a bias of +5% when compared to GOME. In a technical note by Weber et al. (2005), the following was found:

- After careful adjustments of the differences in spectral resolution between GOME and SCIAMACHY a differential scaling factor from GOME FM to SCIAMACHY FM of 0.963(2) (-3.7%) on average was found in the 326.6-335 nm window.
- If no differential scaling between GOME FM (resolution adjusted) and SCIA FM is done, a bias of about +4% in the SCIAMACHY retrieval between SCIA FM and GOME FM is to be expected.

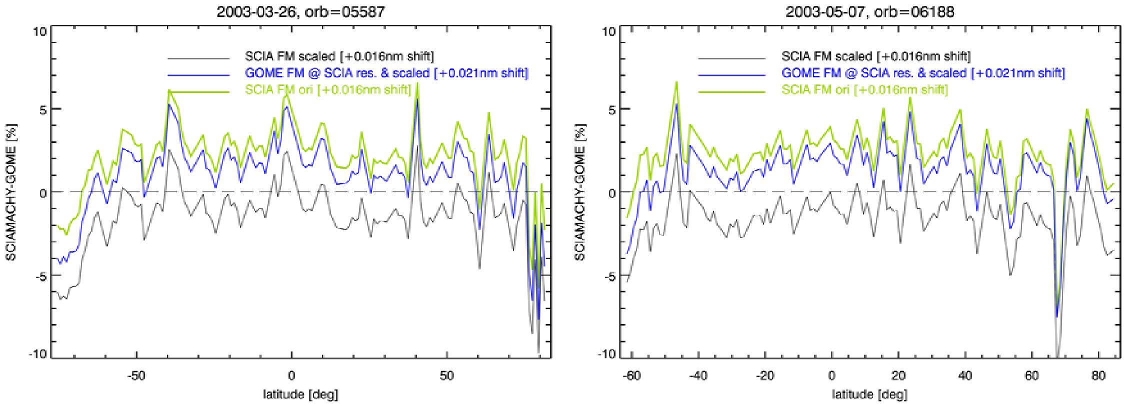

Fig. 4: SCIAMACHY WFDOAS retrieval with various cross-sections compared to GOME WFDOAS (Coldewey-Egbers et al. 2005). The blue and green line show the results from using the GOME FM cross-section scaled to SCIAMACHY FM and the original SCIA FM cross-section from Bogumil et al. (2003). The black line shows the result with the scaled cross-section recommended by Weber et al. (2005).

One should keep in mind that small changes in the spectral windows may change the scaling by several tenths of a percent. In the near future, it is planned to homogenize the flight model cross-section data (SCIA, GOME) in a more rigorous way by including GOME2-FM cross-sections that were measured for all three instruments planned for the Metop-1 to Metop-3. During the GOME2 CATGAS studies more attention has been paid to baseline corrections between individual recordings by regular monitoring the lamp sources. From such an extended study further improvements in the cross-section issue are to be expected.

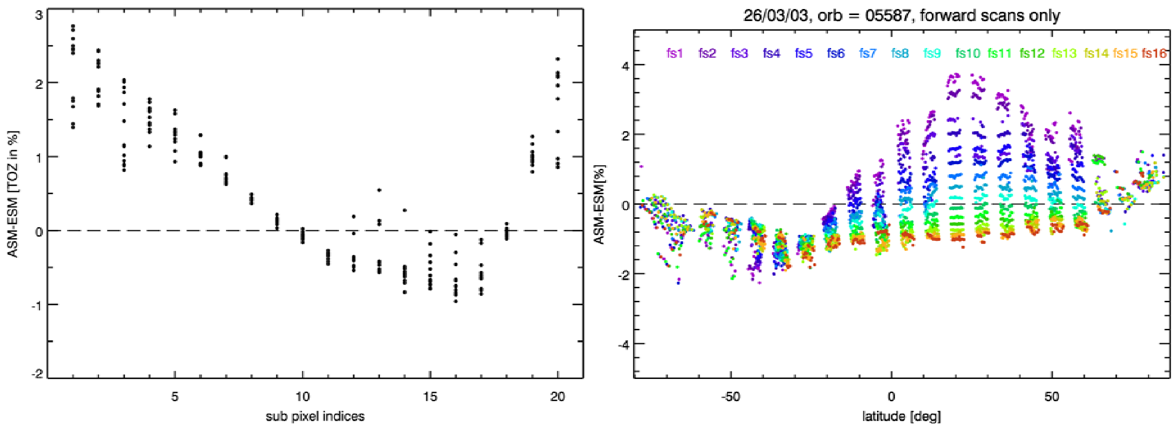

Fig. 5: Left: Scan angle dependence of the SCIA WFDOAS retrieval using ASM and ESM spectral data. Subpixel numbers 1-16 are from east to west in the forward direction, backscan pixels are numbered 17-20. Differences ranges from +3 to –1% going from east to west. Right: Colour coded subpixel results are shown for an entire SCIA orbit.

In a further upgrade of SCIAMACHY WFDOAS, the modified SCIAMACHY ozone cross-section (scaled by –3.7% compared to GOME) and wavelength shifted by 0.016 nm (Weber et al. 2005). The effect from the various cross-sections used in the SCIA retrieval is shown in Fig. 4. Even after optimising the SCIA FM cross-section a bias of –1% to –2% bias with respect to GOME remains as shown in Fig. 4. A similar bias was observed by Eskes et al. (2005) with the TOSOMI algorithm

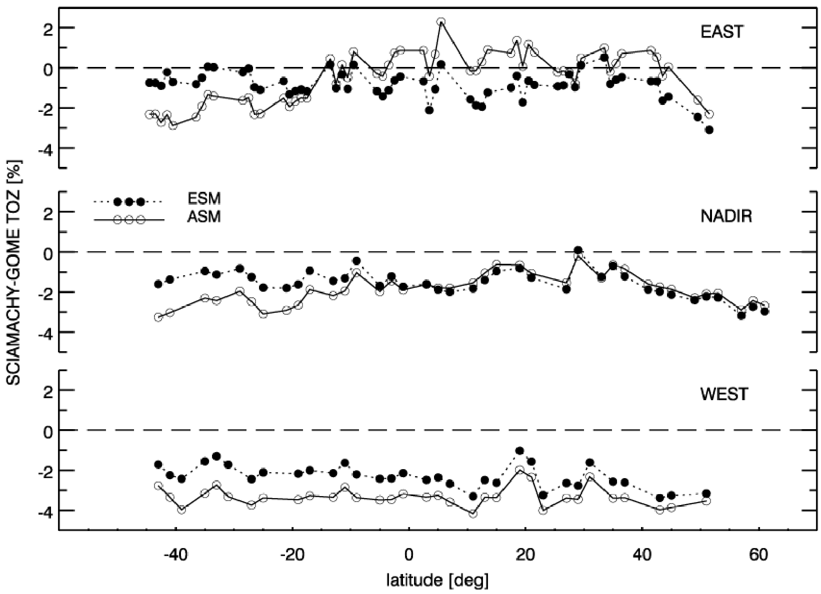

Fig. 6: Comparison between SCIAMACHY WFDOAS and collocated GOME WFDOAS results separated by ASM and ESM spectral radiance data.

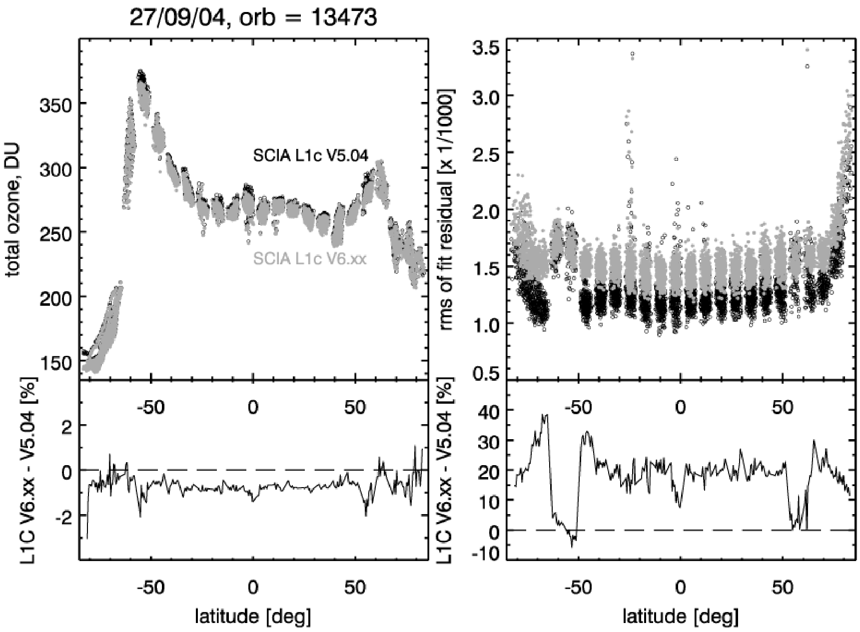

Fig. 7: Total ozone (left) and fit residuals (right) from SCIA WFDOAS retrievals using V5 (black) and V6 level 1 (grey) data for one selected orbit.

and by van Roozendael with SDOAS (personal communications). For minor trace gas retrievals the partially calibrated ASM irradiance and radiance spectra in the DOAS retrieval is recommended to avoid spectral artefacts (de Beek et al., 2004). The results with SCIA WFDOAS used the fully calibrated ESM spectral data. They are needed for retrieving the scene albedo and cloud information from the O2A band (Coldewey-Egbers et al., 2005). A comparison of SCIA WFDOAS applied to ASM spectral data (only for ozone window) with the default ESM data is shown in Fig. 5. ASM and ESM results have also been compared with GOME WFDOAS as shown in Fig. 6. It is evident that the both ASM and ESM retrievals show a scan angle dependence, but the scan angle dependence is more severe with ASM. There appears to be still some problems with the level 1 calibration.

Our algorithm was also tested with the new V6 data that includes updated keydata at a higher spectral sampling. The differences in the SCIA WFDOAS retrievals (using ESM data) is shown in Fig. 7. Differences are on the order of less than 1%, but a larger RMS in the spectral residuals is evident with the new V6. The reason for this is not understood at the moment. Based upon V5 level1 data our SCIA WFDOAS retrieval was compared to several mid-latitude Brewer stations in 2003. All individual comparisons are shown in Fig. 8. In general a good agreement is achieved apart from the constant bias of about –1 to –2% as discussed earlier. No significant seasonal (SZA) dependence is seen. A more extensive validation is planned during Phase B.

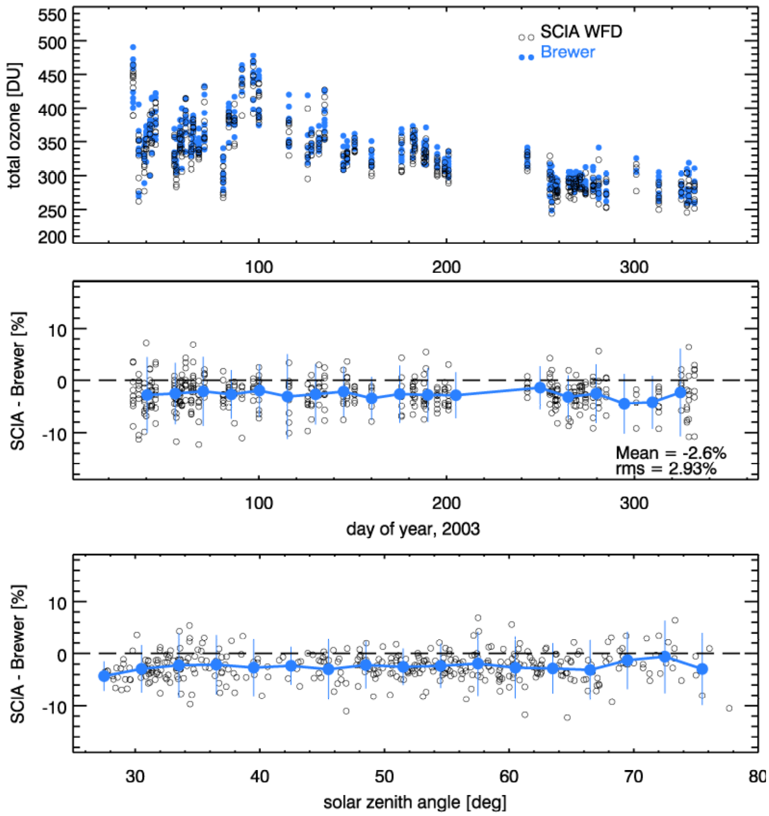

Fig. 8: Comparison of SCIA WFDOAS with collocated European mid latitude Brewer stations in 2003. Top Panel: SCIAMACHY (black) and Brewer total ozone (blue). Middle panel: SCIA Brewer differences in percent. Blues symbols are bi-weekly averages with 2σ variability. Bottom panel. Same as middle panel but as a function of solar zenith angle.

To conclude, the new generation of TO3 algorithms (SDOAS, TOSOMI, WFDOAS) work quite well for SCIAMACHY and are clearly better than V5 Level-2 (see WP 110). However, there are some calibration issues remaining that need to be resolved to further improve SCIAMACHY total ozone.

Verification of minor trace gases

As part of the lv1 verification activities, a new verification data set has been tested in July 2005 using the IUP Bremen DOAS software. Results have been presented in the first progress report and here we only summarize the main results from the verification exercise:

- no significant changes in fit quality and slant columns between spectra calibrated with old and new keydata for any of the scenarios studied.
- in all situations, fits on uncalibrated data (NO_2) or fits including empirical calibration functions (BrO, SO_2, OClO) yield slightly better fit results, although the differences are often not statistically meaningful
- the smallest residuals are obtained if an earth-shine spectrum is used as background
- uncalibrated data with uncalibrated ASM spectrum also yield good results
- calibrated data with calibrated ASM spectrum have slightly larger residuals
- the poorest results are obtained using calibrated data with a calibrated ESM spectrum

These results confirmed previous tests and indicate that the implementation of the solar spectra in the new lv1c data is correct. Results were presented at the SCIAMACHY L1b Verification Meeting on July 14, 2005. (Richter et al. 2005)

In summer 2005 the SCIAMACHY project management (DLR&ESA) decided to focus w.r.t. the nadir trace gas products of O_3 and NO_2 on the GDOAS (SDOAS) implementation. As decided by ESA in summer 2005, the GDOAS implementation for the SCIAMACHY operational data product is planned and the verification of the total column NO_2 product are subcontracted by DLR to BIRA.

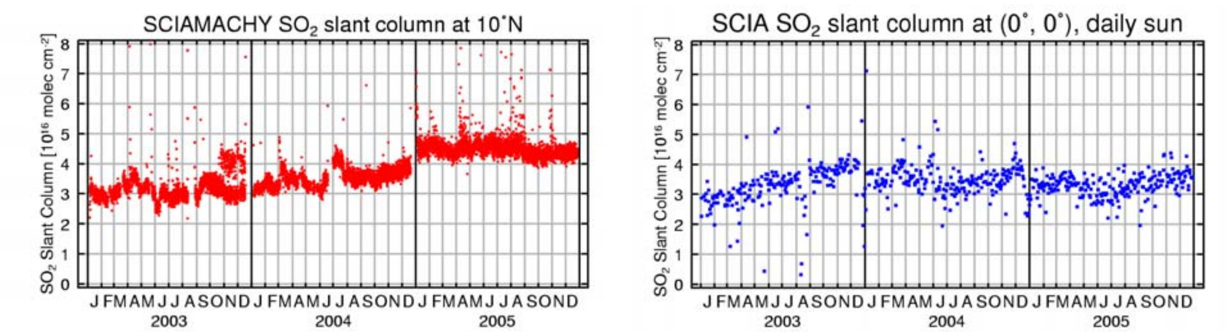

Fig. 9: Impact of ASM background spectra on SO_2 slant columns. Left: fixed background spectra. Right: daily background spectra (see text).

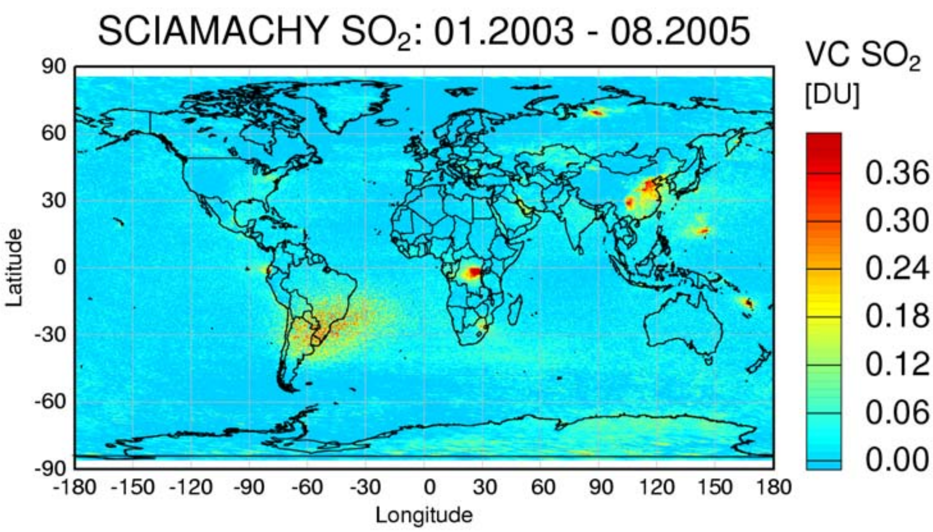

Fig. 10. Global map of SO2 vertical column as seen by SCIAMACHY.

IUP worked in the second half of the year in optimising the retrieval settings for the total column SO2 retrieval to recommend on improvements in the operational data product. The improved DOAS settings use the uncalibrated ASM solar background spectra from December 2002 and a fitting window of 315 – 327 nm. Two airmass factor settings are selectable, one is called the “volcanic” airmass factor, the other the “urban pollution” airmass factor. In addition an offset correction is needed. This is includes a “reference sector” correction to compensate most of the meridional offset variation and a global offset or subtraction of values from a localised reference area in the Pacific. It was also found that a fixed background spectrum avoids jumps due to instrument instabilities but, on the other hand, will introduce a long-term drift (see Fig. 9). When using a daily background spectrum (uncalibrated ASM spectrum) the spectral fits are significantly improved (also for warm detectors during decontamination) and no significant time drift is visible. In summary, the SCIAMACHY SO2 maps show many nice signatures (see Fig. 10) from volcanoes and different large pollution sources. The improved spatial resolution is a significant step forward compared to GOME measurements.

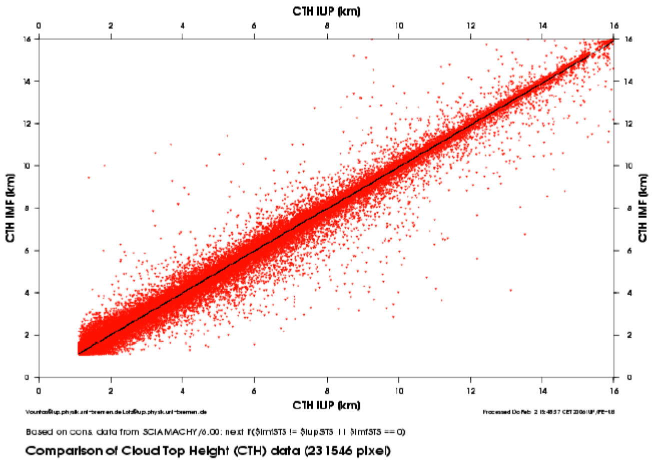

Fig. 11: Comparison of cloud top height (CTH) derived with SACURA for the DLR-IMF and the IUP implementation

IUP also focused on the verification of the operational implementation of the cloud parameter algorithm SACURA as an alternative to FRESCO in support of improved total and tropospheric column trace gas products. Beside cloud fraction and cloud top height, SACURA offers the opportunity to deliver cloud optical thickness and cloud thermodynamic phase information. Currently the implementation focuses on cloud top height and cloud optical thickness. Recently the verification of the operational implementation of SACURA was successfully finished (see e.g. Fig. 11). Over 93% of all retrievals differ to within ± 250 m and over 98% of all retrievals differ within ± 750 m. IUP/IFE recommends to further improve the harmonization in the framework of a maintenance phase.

WP 220 – Verification of operational limb products (Kai-Uwe Eichmann, Alexei Rozanov, Christian von Savigny)

Within this work package global stratospheric ozone and NO2 profiles measured in limb by SCIAMACHY and derived from the operational product were compared to scientific SCIAMACHY-IFE ozone and NO_2 profiles. We performed the verification for all subsets of SCIAMACHY offline profiles in the various data versions released by the DLR SCIAMACHY data processing team in 2005/2006 (see Table 1). Our results were presented at the various Verification Meetings in June 2005, Dec 2005, Feb 2006, and at the SADDU Meeting in Feb 2005 (Bracher et al. 2005, von Savigny et al. 2005b, Eichmann et al. 2005, 2006). These results are in accordance with the findings in WP120. Comparisons of ozone and NO2 profiles v2.4 and 2.5 to IFE products showed in general reasonable agreement but quite a few offline products showed very high (unrealistic) ozone densities. Offline NO2 values were much noisier and showed high densities for nearly all profiles at the bottom of the altitude range retrieved. Results for v2.8 are much better for ozone between 20 and 34 km and NO2 profiles between 26 and 38 km (within 10%). No changes were found for the newer version 5.04 (see Fig. 2 in WP 120) and the preliminary test version 6.0A (Eichmann et al. 2006). As stated in WP120 it is expected that for the new L2 IPF version 6.0 the tangent height problem will be minimised ignificantly and consolidated results of the verification can be expected end of February 2006.

In addition, both operational (v2.4/v2.5) and scientific IUP (v1.61) SCIAMACHY ozone profiles have been extensively and systematically compared to SAGE II v6.2 by us and also to other independent ozone profile measurements by other groups. The study has been published in Brinksma et al. (2006) and was discussed in detail in the first progress report of this paper. All in all IFE profiles from v1.6 are about 6% lower than SAGE II (averaged from 16 to 40 km), show best results between 30 and 35 km altitudes, and are in much better agreement than the operational ozone profiles from v2.4 and 2.5. Results for IFE-NO2 profile validation and details on the retrieval algorithm have been published in two publications (Rozanov et al. 2005, Bracher et al. 2005f). IFE-NO2 profiles validated with HALOE v19 showed an agreement to within 12% at 22-33 km.

Task 4 – Cross Comparisons to MIPAS and GOMOS

For WP 410, WP 420 and WP 430 (also for WP 220) the scientific IUP SCIAMACHY (V1.6 and V1.0, respectively), MIPAS IMK (V2_O3/NO2_2), and GOMOS ACRI (v6.0a) ozone and NO2 profiles have been cross-compared systematically. The results have been written up in a paper which has been published by Bracher et al. (2005b). This study was done in cooperation with scientist from the "Institut für Meteorologie und Klimaforschung" (IMK) at the Research Center Karlsruhe and from the Instituto de Astrofisica de Andalucia in Granada. Within the framework of SCIAMACHY processor Lv0-1 and Lv1-2 verification, we compared the operational SCIAMACHY ozone and NO2 profiles versions 2.8, 5.04 (internally named 3.0), 6.0A to operational MIPAS ozone v4.62 and GOMOS v4.0/v4.02 ozone profiles and MIPAS NO2 v4.62 profiles. We already described in detail the comparisons with SCIAMACHY v2.8 profiles in the first progress report of this project, so we focus here on the comparisons with the newer SCIAMACHY versions. In addition, all our comparisons concerning SCIAMACHY v2.8, IUP limb and lunar occultation ozone and NO2 profiles with MIPAS IMK scientific data and operational data v4.61/4.62 were presented by H. Bovensmann at the SACADA Final Meeting held at 27 Oct 2005 at the Rheinisches Institut für Umweltforschung at the University of Köln (Bracher et al. 2005a).

WP 410 – Comparisons of SCIAMACHY O3 profiles with MIPAS (Astrid Bracher)

We compared SCIAMACHY ozone profiles v2.8, 5.04 and 6.0A with MIPAS v4.62 profiles. Only data from January and March 2004 could be compared because the MIPAS instrument was not measuring during other times. MIPAS operational trace gas profiles also have a tangent height offset but in the other direction as shown by Clarmann et al. (2003). From MIPAS measurements temperature and pressure profiles are retrieved. Validations of MIPAS ozone profiles using the retrieved pressure levels as altitude coordinate show very good results, e.g. our own comparisons to SAGE II show an agreement for the whole MIPAS v4.61/4.62 data set to within 5% (RMS <10%) from -0.6 to 70 hPa (see Cortesi et al. 2005). So one has to bear in mind that by comparing SCIAMACHY with MIPAS v4.61/4.62 that both data sets without tangent height corrections and errors in the altitudes will add up (SCIAMACHY altitudes mostly to high, MIPAS' mostly to low). A total of 77 matches were found where collocations were considered to be within 500 km and correlated data were measured in the same orbit. For the comparisons with SCIA test version 6.0A only 12 collocations were available. The SCIAMACHY v2.8 and 5.04 have been tangent height corrected using the TRUE-method by Kaiser et al. (2005). All matches were found between 42°S to 47°N. One comparison with all three SCIAMACHY versions is seen in Fig. 12 to the left. As for comparisons shown in WP 120, 220, 420, and 430,results indicate that no tangent height correction was applied in the test version 6.0A. Statistical results presented in Fig. 12 middle and right panel between 20 and 50 km show the same results for tangent height corrected v2.8 and 5.04 with a negative offset of 7 to 25% (RMS of 5-12%) to MIPAS. This negative offset might be due to the fact that the MIPAS tangent heights have not been corrected as well. Therefore results from comparisons to GOMOS profiles that do not need tangent height corrections will tell us more.

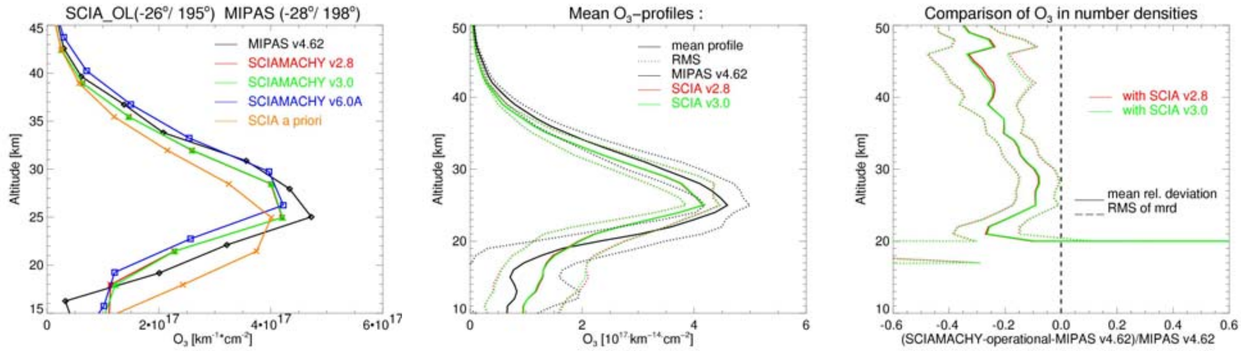

Fig. 12: Left panel: Comparison of a collocated SCIAMACHY ozone profile retrieved by different offline data versions with MIPAS version 4.62 from 15 Jan 2004. Statistics are shown for all collocations with data v2.8 and 5.04 (here named 3.0) from SCIAMACHY with MIPAS v4.62 verification orbits in 2004 with mean profiles (middle panel) and mean relative deviation and RMS of mean relative deviation (right panel). For SCIAMACHY v2.8 and v3.0 a tangent height shift was applied using the TRUE-method by Kaiser et al. 2005.

WP 420 - Comparisons of SCIAMACHY O3 profiles with GOMOS (Astrid Bracher)

We compared SCIAMACHY ozone profiles v2.8, 5.04, 6.0A with GOMOS v4.0 (Jan & Mar 2004 matches) and 4.02 (for Jun & Sep 2004 matches). GOMOS ozone profiles show a high data quality from 19 to 64 km with a small negative bias between 0 to 5% (Meijer et al. 2004, Bracher et al. 2005c). Comparisons are useful for evaluating the new operational SCIAMACHY offline data versions. A total of 24 matches were found with the same spatial collocation criterion as in WP410 and measurements from the same day. For the comparisons to SCIAMACHY v6.0A only data for six collocations were available. All matches are in the southern hemisphere. As for comparisons made in WP 120, 220, 410, and 430, results are similar. Results for one collocation are shown in Fig. 13 left panel with no tangent height correction for the SCIAMACHY data applied. All three SCIAMACHY versions show identical results above 20 km and a clear shift is seen between the SCIAMACHY and GOMOS profiles. The statistical results show that v2.8 and 5.04 profiles without tangent height corrections are within –18 to +21% (RMS 6-19%) of GOMOS profiles from 22 to 41 km (Fig. 12 middle panel). With tangent height corrections (Fig. 12 right panel) results improve to within –13 to 4% (RMS 4-13%). V5.04 shows slightly better agreement than v2.8.

Results demonstrate clearly the need for a tangent height correction to be implemented in the operational processing as pointed out at the past various verification meetings (e.g. see Bracher and Bramstedt 2005a, 2005b, 2005c, 2005d, 2006, Bracher al. 2005c, Eichmann et al. 2005, Eichmann et al. 2006). Such a correction is expected from the upcoming v6.0 data.

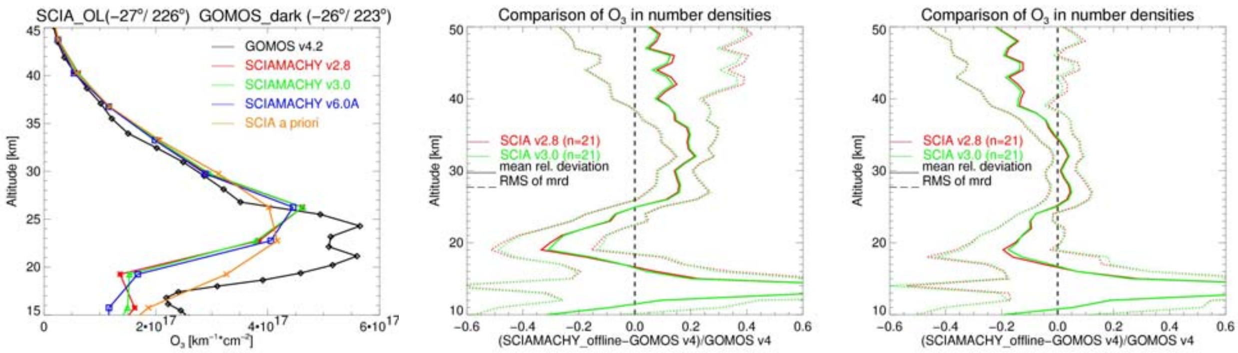

Fig. 13: Comparison of a collocated SCIAMACHY ozone profile retrieved by different offline data versions with GOMOS data version 4.02. Example in left panel and difference between collocated ozone profiles (total of 21) of SCIAMACHY v2.8 and 5.04 (here named 3.0) and GOMOS v4.0/4.02 with mean relative deviation and RMS of mean rel. deviation without (middle panel) and with (right panel) tangent height corrections applied to SCIAMACHY data using the TRUE-method by Kaiser et al. 2005.

WP 430 – Comparisons of SCIAMACHY NO_2 profiles with MIPAS (Astrid Bracher)

We compared SCIAMACHY NO2 profiles v2.8, 5.04 and 6.0A with MIPAS v4.62. A total of 17 collocations, all from the tropics/subtropics, were found with the same collocation criteria as in WP410. The differences of solar zenith angles (SZA) for the collocated measurements were required to be below 5° in order to minimise the influence of the NO2 diurnal cycle. For comparisons to SCIAMACHY 6.0A only 3 collocations were available and the comparisons were similar to those with version 3.0 (not shown). Statistical results (not shown) for v2.8 already show reasonable results with SCIAMACHY v2.8 NO2 profiles with a tangent height correction applied agree to within –16 to +7% (RMS 10 to 27%) from 26 to 38 km altitude. Unfortunately results are worse for v5.04 (–25 to 0% and RMS of 10-29%). One has to keep in mind that the SCIAMACHY NO2 profile maximum is expected to be higher than MIPAS because collocated SCIAMACHY measurements were recorded at higher SZA than MIPAS. In addition we need a larger sample of reprocessed SCIAMACHY data in order to evaluate the quality of the SCIAMACHY operational data product. We expect that more operational NO2 limb profile data from SCIAMACHY will be available in the near future. A more extensive and detailed validation is then planned for Phase B.

Task 5 – Validation of SCIAMACHY Mesopause Temperatures with Ship-Based Measurements

WP 510 – Retrieval of mesopause temperature data from SCIAMACHY (Christian von Savigny, Kai-Uwe Eichmann)

SCIAMACHY mesopause temperature data have been retrieved within the SADOS project from nighttime SCIAMACHY limb level-1 data for the entire data sets from Oct 2002 to Nov 2005. The method to derive mesopause temperatures has been described in detail in von Savigny et al. (2004). Fig. 14 is showing an example of a SCIAMACHY OH (3-1) nighttime emission spectrum at 85 km tangent height measured collocated to GRIPS measurements taken on the same day on Polarstern and also the model spectral fit. Fit results from SCIAMACHY are in very good agreement with the forward model.

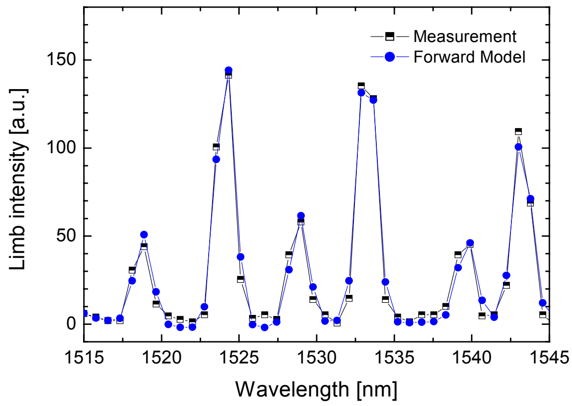

Fig. 14: Sample spectral fit for a SCIAMACHY limb measurement on October 20, 2005, during orbit 19034.

WP 520 – Latitudinal OH-Mesopause temperature data set (Katrin Hoeppner, Michael Bittner)

The German Remote Sensing Data Center (DFD) of the German Aerospace Center (DLR) has developed a mobile Infrared-Spectrometer GRIPS 4 (GRound-based Infrared P-branch Spectrometer). The measurement technique makes use of the so-called airglow: In the upper mesosphere atomic hydrogen reacts with ozone

$$O_3 + H \rightarrow O_2 + OH^* \text{ (exothermic 3.32 eV)}$$

forming excited hydroxyl molecules (OH*) in a layer of ~8 km thickness and a peak altitude of ~87 km. Chemically excited OH molecules emit near-infrared radiation from several rotational-vibrational transitions. These emissions are measured by ground-based instruments during nighttime (OH* concentrations during daytime are negligible). The measuring technique also allows measurements even if light clouds or haze are present (details in Bittner et al. (2000, 2002)).

A case study comparing hydroxyl rotational temperatures (OH*) from SCIAMACHY to GRIPS 1 data (precursor of GRIPS 4) above Hohenpeissenberg (47.5°N / 11.1°E) has already been performed and yielded a good agreement (von Savigny et al., 2004). In order to validate SCIAMACHY data over different climate zones with one instrument a campaign with the mobile GRIPS 4 instrument on board the German research vessel “Polarstern” on its cruise from Bremerhaven (53.6°N, 8.6°E) to Cape Town (34.0°S, 18.5°E) from 13 October until 17 November 2005 (ANT XXIII/1, Fig. 15) was conducted. SCIAMACHY data therefore can be validated over a wide latitude range along the north-south route across the equator from Europe to South Africa. Another objective of this campaign was to generate a data series during the expedition which inherently is of scientific interest concerning the investigation of atmospheric dynamics. One specific question was to quantify smaller scale temperature fluctuations (gravity waves) versus latitude. On board “Polarstern” GRIPS 4 measured continuously every night. The temporal resolution was about 3 minutes. Fig. 16 shows a typical OH* spectrum. The rotational temperature

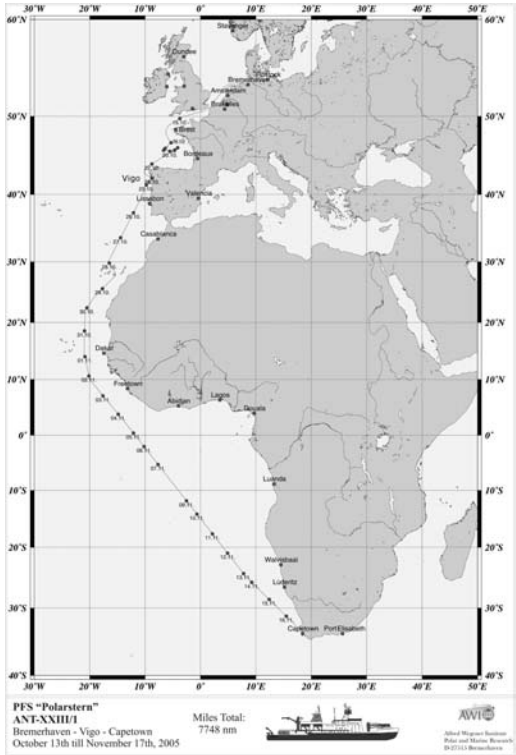

Fig. 15: Cruise plot of the "Polarstern" expedition ANT XXIII/1 from Bremerhaven (53.6°N, 8.6°E) to Cape Town (34.0°S, 18.5°E) from 13 October until 17 November 2005.

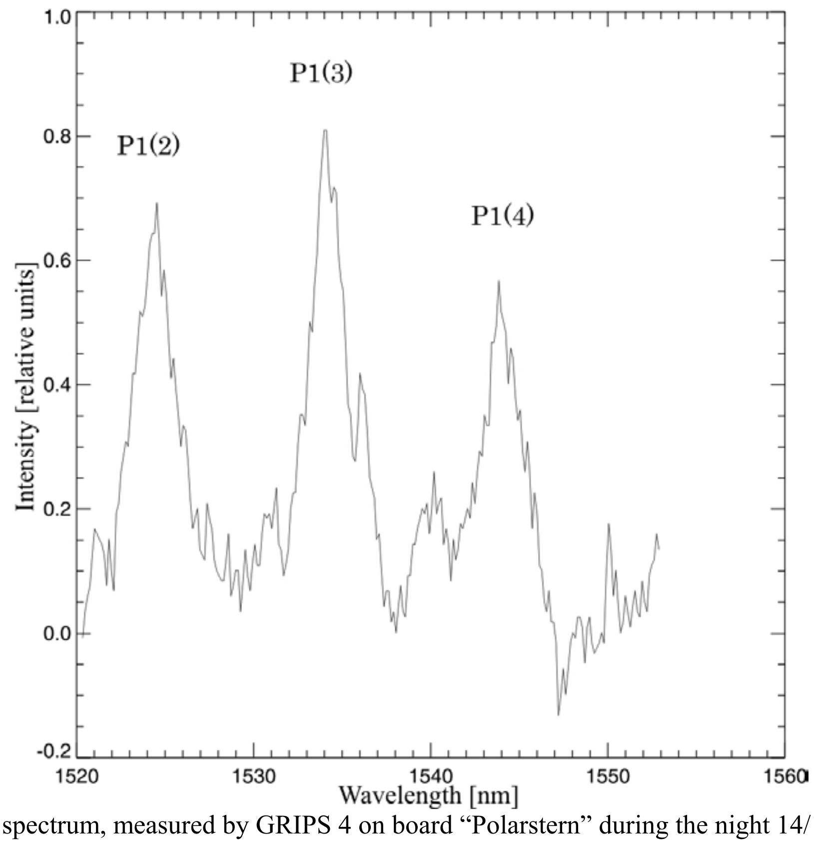

Fig. 16: Typical OH* spectrum, measured by GRIPS 4 on board "Polarstern" during the night 14/15 October, 2005.

was derived from the OH*(3,1) vibrational P-branch using the relative intensities of the shown three rotational P1(2), P1(3), and P1(4) lines at 1524 – 1543 nm.

WP 530 – Validation of SCIAMACHY mesopause temperature data with ground and ship-based data (Christian von Savigny, Astrid Bracher)

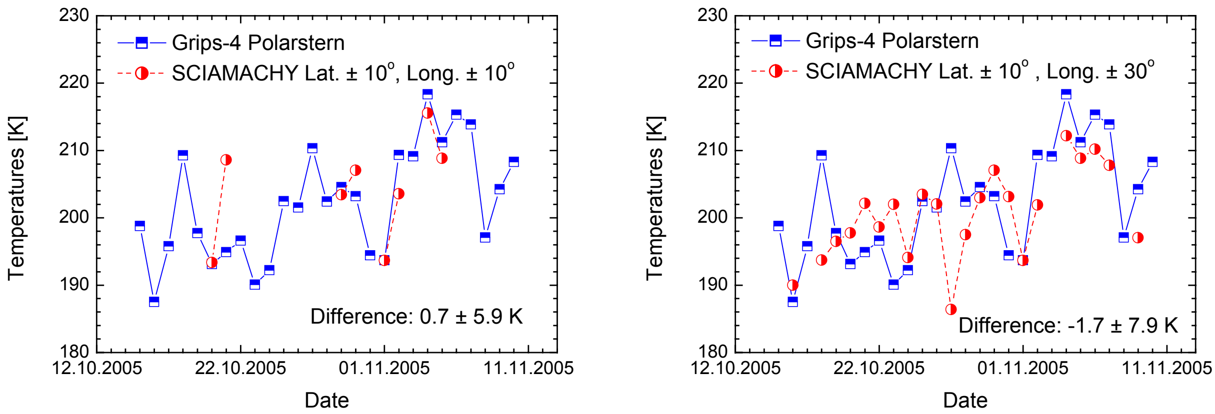

Fig. 17: Comparison of GRIPS-4 and SCIAMACHY OH*(3-1) rotational temperatures during the Polarstern cruise. The GRIPS-4 values are night time averages, and the SCIAMACHY temperature values are averages over all SCIAMACHY measurements within 10º latitude/30º longitude (left panel) and 10º latitude/10º longitude (right panel).

The SCIAMACHY mesopause night time temperatures have been validated with latitudinal data set from the GRIPS experiment on the research vessel "Polarstern". Collocated measurements between SCIAMACHY and GRIPS-4 are available for most days during the RV Polarstern cruise from October 15 to November 11, 2005. For coincidences within 10º in terms of both latitude and longitude the number of coincidences were 8, and the mean difference was 0.7 K with a standard deviation of 5.9 K (Fig. 17 left). Except for October 21st, when SCIAMACHY and GRIPS-4 differ by 13.7 K, the agreement is very good. For coincidences within 10º in terms of latitude and 30º in terms of longitude the mean difference is –1.7 K with a standard deviation of 7.9 K (Fig. 17 right). The only day with significant differences is October 27. The reason for this difference is yet to be identified.

The apparent differences may be due to several different reasons. First, the spatial extent of the observed air volumes differs significantly. GRIPS-4 has a FOV of about 20 by 20 km at mesopause levels, whereas SCIAMACHY averages over about 500 by 1000 km. Secondly, SCIAMACHY looks through the OH* emission layer along a slant path in limb geometry. Therefore, depending on the actual vertical OH*(3-1) emission rate profile, the ground-based and satellite-borne rotational temperature retrievals may be weighted differently. This effect was minimized by employing SCIAMACHY emission spectra at a tangent height, for which the weighted emission altitudes are nearly identical for both viewing geometries (see von Savigny et al. 2004). Thirdly, different sets of Einstein coefficients are used for the GRIPS and the SCIAMACHY retrievals. The GRIPS temperature retrievals use the Mies (1974) Einstein coefficients, whereas for the SCIAMACHY temperature retrievals the values by Kovacs (1969) are employed. However, this leads to mean differences on the order of 1 K (von Savigny et al., 2004) and may therefore be considered a minor effect.

SUMMARY AND RECOMMENDATIONS:

From the validation, verification, and ENVISAT atmospheric satellite sensor inter-comparison studies done within WP 100, WP 200 and WP 400 valuable results were received to evaluate the operational products of total ozone, ozone profiles, NO2 profiles, and solar irradiance:

We performed an extensive validation and verification of SCIAMACHY operational ozone columns and results were published in Bracher et al. (2005d) and presented at the AURA Science Meeting. Further work concentrated on the influence of different settings and calibration versions of level-1 data on the retrieval of SCIAMACHY ozone columns and we participated in cross comparisons of our own algorithm to other scientific SCIAMACHY algorithms.

Five offline versions of limb data released by DLR during Phase A were validated, verified and cross compared to collocated data of the two other atmospheric ENVISAT sensors GOMOS and MIPAS. Results showed clearly that the data version were improving and that there is a clear need for a tangent height correction to be implemented as planned in the upcoming offline v6.0. We participated in a large study on validating SCIAMACHY-IUP and offline ozone profiles (peer-reviewed published now in Brinksma et al. 2006) and also our studies on the retrieval and validation of SCIAMACHY-IUP NO2 profiles were published (Rozanov et al. 2005, Bracher et al. 2005f). In addition, we performed cross comparisons of SCIAMACHY-IUP, MIPAS-IMK and GOMOS-operational O3 and NO2 profiles and published these results in a peer-reviewed paper (Bracher et al. 2005b).

The effect of improving the absolute radiometric calibration by generating new radiometric key data on SCIAMACHY irradiance data was studied in detail and validation with different solar satellite spectra and the spectrum used in the atmospheric radiative transfer model MODTRAN 3.7 was carried out. Results have been summarized in Skupin et al. (2005). In addition, the monitoring of the SCIAMACHY instrument performance with time based upon solar irradiance measurements has been successful.

An entire three-year data of OH-mesopause temperatures have been retrieved from SCIAMACHY night time measurements retrieved at IUP. These measurements were compared with results from a Polarstern cruise with the DLR instrument GRIPS that provided a meridional cross-section of OH-mesopause temperature data. In general very good agreement between SCIAMACHY and Polarstern GRIPS data was found. Further studies are underway for the scientific interpretation of the data

Our findings and recommendations to the various data products from SCIAMACHY were presented at the SSAG and SCIAVALIG meetings in Oct 2005 and at all SCIAMACHY Verification and SADDU meetings held during Phase A. Our recommendations have been detailed in the WPs of this report.

Our main recommendations to ESA are the following:

- In addition to generally improving the operational ozone columns from SCIAMACHY by using advanced fourth generation algorithms like SCIA WFDOAS, SDOAS, and/or TOSOMI, further work is needed to better understand the strong scan angle dependence in the retrieved total column as well as the observed bias of -1.5% w.r.t. GOME and groundbased data. Both effects are believed to be related to calibration of the level-1 data. As fast as possible the validation reference set and then the whole data set shall be reprocessed.

- Since verification and validation of the latest prototype offline limb ozone data versions 2.8 and 5.04 showed a reasonable quality despite the tangent height offset, we recommend to implement the new data version L2 IPF version 6.0 (incl. tangent height corrections) and reprocess as fast as possible the validation reference set and then also the whole data set. For this data version the tangent height problem should be minimised. We expect similar improvements for other trace gas profiles such as BrO and NO2.
- With respect to the unique results from the mesopause temperature data set from SCIA OH-Meinel bands emissions and our discussions at various meetings and conferences, we identified a clear need for a global mesopause temperature data set from SCIAMACHY measurements covering solar maximum and solar minimum conditions. Potential users are coming from the international CAWSES community (http://www.bu.edu/cawses). To establish such a service (incl. routine processing, quality control, validation, documentation, user support etc.) we estimate an initial effort of approx. 2 person years, resulting in a ROM cost of 170 k€ (incl. travel, hardware etc.). As this is out of scope of funding of the current project, we would like to propose to ESA to check availability of additional funding for such a required service.

OUTLOOK TO PROJECT PHASE B:

The following task are planned for phase B for the various work packages:

- Apart from further clarification of the impact of the level 1 calibration on WFDOAS, further work is planned to characterize the effect of the new SACURA/OCRA cloud algorithm on TO3. As part of the verification activities both FRESCO and SACURA/OCRA algorithms are compared in the WFDOAS retrievals. The ongoing validation activities will be continued with emphasis to comparisons of GDP V4 (SDOAS) to be implemented for SCIAMACHY operational retrieval with OMI (NASA and KNMI retrievals) as well as updated SCIAMACHY WFDOAS (WP110 and WP210).
- Comparisons of minor nadir trace gas products from IFE with SCIAMACHY v6.0 (WP210)
- Comparisons of the new SCIAMACHY v6.0 ozone profiles to HALOE, SAGE II, OMI profiles (if available - all WP120), SCIAMACHY-IFE (WP220), MIPAS (410) and GOMOS (WP420)
- Comparisons of the new SCIAMACHY v6.0 NO2 profiles to SCIAMACHY-IFE (WP220) and MIPAS (WP430)
- Validation of solar irradiance from new level-1 data version 6.0 with spectra from SIM, SOLSPEC, SOLSTICE, SUSIM and the high resolved Kurucz spectrum (WP130)
- Comparisons of IFE-SCIAMACHY mesopause night time temperature data with selected groundbased data from the two GRIPS-experiments at Hohenpeißenberg and Wuppertal and the "Polarstern" GRIPS dataset (WP530).

Furthermore results from Phases A and B are written up in the progress and final report of phase B, presented at various meetings (e.g. EGU 2006, ESA Atmospheric Science Meeting, COSPAR 2006) and various peer-reviewed publications are planned.

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PARTICIPATION IN MEETINGS:

In order to exchange information, present our results and recommendations to the agencies with other teams within the SCIAMACHY, MIPAS and GOMOS validation and verification teams we attended the following meetings:

- SADDU Meeting, 17 Feb 2005, DLR Oberpfaffenhofen, Wessling, Germany
- Verification Meeting for SCIAMACHY L2 processor upgrade for limb products, 16 June 2005, IUP/IFE, University of Bremen, Bremen, Germany
- SCIAMACHY L1b/c Verification Meeting, 14 July 2005, DLR Oberpfaffenhofen, Wessling, Germany
- SSAG Meeting, 5 Oct 2005, NIVR, Delft, The Netherlands
- SCIAVALIG Meeting, 6 Oct 2005, KNMI, De Bilt, The Netherlands
- SACADA Final Meeting, 27 Oct 2005, Rhenisches Institut für Umweltforschung an der Universität zu Köln, Köln, Germany
- AURA Science Meeting, 8-10 Nov 2005, The Hague, The Netherlands
- SCIAMACHY L1b and L2 Verification Meeting, 14 December 2005, DLR Oberpfaffenhofen, Wessling, Germany
- SADDU Meeting, 11-12 Jan 2006, IUP/IFE, University of Bremen, Bremen, Germany
- SCIAMACHY L1b and L2 Verification Meeting, 7 February 2006, DLR Bonn, Bonn, Germany

WORK PERFOMANCE WITHIN WORK, TIME AND FINANCING PLAN:

All work has been mainly carried out within the time plan unless operational data were not available in time as reported in the WPs. Phase A work was carried out in accordance with the financial plan.

COOPERATIONS WITH OTHER SCIENTISTS:

The work performed within this project was done in cooperation with many scientists. Especially with the following scientist the cooperation was very fruitful:

- Michel van Roozendael, Christophe Lerot (both from BIRA), and Henk Eskes (KNMI) on improving SCIAMACHY ozone column retrievals
- AME-Team of „Institut für Meteorologie und Klimaforschung (IMK) am Forschungszentrum Karlsruhe“ within the ENVISAT cross comparisons made for WP 400
- Manuel Lopez Puertas, Bernd Funke, MariLiza Koukuli from the Instituto de Astrofisica de Andalucia in Granada within the ENVISAT cross comparisons made for WP 400
- the MIPAS ozone validation paper team (see author list on Cortesi et al. 2005) on assessing the quality of MIPAS ozone profiles
- Ellen Brinksma and Ankie Piters on assessing the quality of SCIAMACHY ozone profiles
- the MIPAS NO2 validation paper team (see author list on Wetzel et al. 2005) on assessing the quality of MIPAS ozone profiles
- Gilbert Barrot (ACRI-GOMOS level-2 processing) within the ENVISAT cross comparisons made for WP 400

PUBLICATION LIST ARISED FROM WORK WITHIN THIS PROJECT:

1. Bracher A., Amekudzi L., Bramstedt K., Rozanov A., von Savigny C., Sinnhuber M. (2005) Cross validation of O3 and NO2 profiles measured by MIPAS (IMK and 4.61) and SCIAMACHY (IUP and v2.8). Presentation at the SACADA Final Meeting, 27 Oct 2005, Rhenisches Institut für Umweltforschung an der Universität zu Köln, Köln, Germany.
2. Bracher A., Bovensmann H., Bramstedt K., Burrows J. P., von Clarmann T., Eichmann K.-U., Fischer H., Funke B., Gil-López S., Glatthor N., Grabowski U., Höpfner M., Kaufmann M., Kellmann S., Kiefer M., Koukouli M. E., Linden A., López-Puertas M., Mengistu Tsidu G., Milz M., Noël S., Rohen G., Rozanov A., Rozanov V.V., von Savigny C., Skupin J., Sinnhuber M., Steck T., Stiller G. P., Wang D.-Y., Weber M., Wuttke M. W. (2005) Cross comparisons of O3 and NO2 profiles measured by the atmospheric ENVISAT instruments GOMOS, MIPAS, and SCIAMACHY. Advances in Space Research 36(5): 855-867.
3. Bracher A., Bramstedt K. (2005) Validation of SCIAMACHY-Offline O3 profiles v2.4/2.5 with SAGE II (v6.2). Presentation at the SADDU Meeting, 17 Feb 2005, DLR Oberpfaffenhofen, Wessling, Germany.
4. Bracher A., Bramstedt K. (2005) Validation of SCIAMACHY-Offline O3 profiles (v2.8) from May 2005 with HALOE (v19) and SAGE II (v6.2). Presentation at the "Verification Meeting for SCIAMACHY L2 processor upgrade for limb products", 16 June 2005, IUP/IFE, University of Bremen, Bremen, Germany.
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13. L.N. Lamsal, M. Weber, G. Labow, and J.P. Burrows (2005) Influence of ozone and temperature climatology on the accuracy of satellite total ozone retrieval, J. Geophys. Res.: submitted.
14. Noel S. (2005) Verification of SCIAMACHY Irradiances (PCR 4). Technical note to ESA from the Institute of Environmental Physics (IUP).
15. Noel, S. (2005) Determination of correction factors for SCIAMACHY radiances and irradiances (version 5.2), Tech. Rep. IFE-SCIA-SN-20050203_IrrRadCorrection, IFE/IUP.
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17. Rozanov A., Bovensmann H., Bracher A., Hrechanyy S., Rozanov V., Sinnhuber M., Stroh F., Burrows J.P. (2005) NO_2 and BrO vertical profile retrieval from SCIAMACHY limb measurements: sensitivity studies. Advances in Space Research 36(5): 846-854
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21. M. Weber and L.N. Lamsal (2005) Recommendations of ozone-cross-sections for SCIAMACHY ozone retrieval in the 325-335 nm spectral window. Technical Note, Institute of Environmental Physics, University of Bremen, Bremen, Germany (www.iup.uni-bremen.de/UVSAT_material/manuscripts/weber_Technote_SCIAO3X_200512_Iss1.pdf).