SCIAMACHY VALIDATION SUMMARY

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ABSTRACT

In early 2004, preliminary validation was conducted for all SCIAMACHY data products: those generated operationally by ESA's Envisat ground segment and those generated non-operationally at several scientific institutes. Results as presented and discussed during the second Workshop for Atmospheric Chemistry Validation of Envisat (ACVE-2) in May 2004, are summarised here. The main conclusion is that the SCIAMACHY products have improved considerably since the First Envisat Validation Workshop in December 2002, both in number and in quality. All validation results are however still preliminary in the sense that: a) data sets from longer periods with better sampling are necessary to detect seasonally varying errors and other medium-scale effects; b) not all available validation sources were properly used, due to lack of time; and c) comparison results reported here do not always reflect the expected final quality of the products as some of the SCIAMACHY data products are not generated with state-of-the-art processors (due e.g. to delays in the delivery of accurate level-1 data). Various recommendations for product improvement have been collected during the meeting and are summarised here.

Note: Due to the short time available for validation before the ACVE-2, several contributions on SCIAMACHY validation in this proceedings have evolved since their presentation at the ACVE-2, so that conclusions for individual products may be different than in the original presentations. This summary paper is however mainly based on the presentations, and not on the papers in these proceedings. Therefore, we refer you to the separate product papers for more up-to-date conclusions on each product.

1. INTRODUCTION

The validation of SCIAMACHY products is performed by more than 30 European and non-European institutes. The validation of these products is a long-term exercise, continuing throughout the life time of the instrument and beyond. A detailed validation plan is published by the SCIAMACHY Validation and Interpretation Group (SCIAVALIG), a subgroup of the SCIAMACHY Science Advisory Group, Kelder et al. (2002). In these proceedings there are many contributions on SCIAMACHY validation, showing the current (May 2004) status of the product quality. With the availability of a larger dataset and future versions of the processor, these intermittent results will be completed and possibly change. The most recent results on validation can be found on the international SCIAMACHY validation web site (http://www.sciamachy-validation.org).

In Fig. 1 the measurement sequence of SCIAMACHY is shown between March 2002 (launch) and May 2004. SCIAMACHY proved to be a very stable instrument with only a few short periods of 'off-time' (marked in red) during the first two years after launch. Regular decontamination (marked in blue) is performed to get rid of a small ice layer on the NIR detectors (with success, see Sect. 2.)

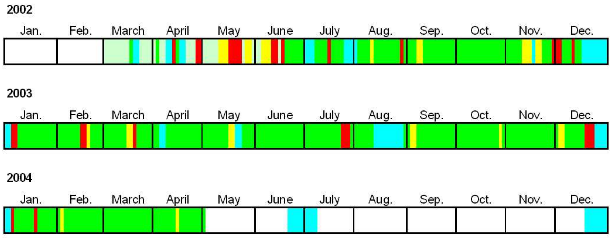

Figure 1. Status of SCIAMACHY operations from launch (28-2-2002). In green are the periods where nominal measurements were performed, light-green are dedicated commissioning phase measurements, in light-blue are the decontamination periods with reduced measurement accuracy, in yellow are the periods that Envisat as a whole was off or that there were orbital control manoeuvres, in red are the periods that the SCIAMACHY instrument was off. Picture from Chlebek et al. (2004).

The SCIAMACHY data available for this workshop is a set of 1927 states[1] measured between July and December 2002, and chosen to coincide with measurements from dedicated aircraft and balloon validation campaigns and from selected ground-based instruments.

This set of states was processed to a level 1b and a level 2 data set by the operational processor ("operational" products). In addition the level 1b data set was processed to level 2 by various scientific institutes with their own algorithms ("non-operational" or "scientific" products), and kindly provided to the validation teams for further analysis. The available operational and non-operational SCIAMACHY level 2 products are listed in Table 1. Both operational and non-operational products were analysed by the various presenters in this workshop. The results for

[1]measurement blocks with consecutive measurements, with a total duration of approximately 1 minute, in nadir corresponding to approximately 960×400 km^2

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level 1 data are summarised in Sect. 2. The results for level 2 data are summarised in Sect. 3. to 5.

Table 1. The operational (OP) and non-operational (NOP) SCIAMACHY level 2 products available for validation at this workshop. In the column 'OP', a cross (X), indicates that the product is generated by the operational processor. In the column 'NOP-institutes', the scientific institutes are listed which have generated the products, using their own algorithms.

product	**OP**	**NOP-institutes**
O_3 column	X	BIRA, KNMI
NO_2 column	X	BIRA, IFE, IUP-Heid, KNMI, SAO
BrO column	X	BIRA, IFE, IUP-Heid
SO_2 column		BIRA, IFE
OClO column		IFE, IUP-Heid
H_2O column		IFE, MPI
cloud cover	X	IUP-Heid, KNMI
cloud top		IFE, KNMI
AAI		KNMI
AOT		IFE
CO column		IFE, SRON
CH_4 column		IFE, SRON
N_2O column		IFE
CO_2 column		IFE
O_3 profile	X	IFE
NO_2 profile	X	IFE, SAO
BrO profile		IFE, SAO

2. STATUS OF LEVEL 1 PRODUCTS

Some of the level 2 products are quite sensitive to level 1 errors. A number of instrumental and calibration issues are known to affect the quality of the level 2 products. The major issues are:

- radiance offset: The absolute calibration of the solar irradiance is not correct, as was shown in a poster by J. Skupin (private communication). The error observed in the Earth reflectance (see Sect. 2.1), i.e. the ratio of the Earth radiance and the Solar irradiance, cannot be explained by this effect alone, showing that also the absolute calibration of the Earth radiance is not correct and that it is different from the error in the absolute calibration of the Solar irradiance. This mostly affects the retrieval of aerosol products and some of the cloud products, which use the absolute value of the reflectance in their retrieval. The cause of this problem is still under investigation. In the meantime correction factors as a function of wavelength have been established by KNMI, IFE and ESA, see, e.g., Tilstra et al. (2004), Acarreta et al. (2004).
- polarisation correction: The correction applied for polarisation sensitivity is not adequate yet. This can be seen from remaining polarisation sensitivity structures in the spectra after the correction has been applied. This mostly affects the retrieval of species with spectral signatures in the same wavelength regions as the polarisation sensitivity structures, like HCHO, OClO, BrO. The cause of this problem is still under investigation. For OClO and BrO the fitting window has been adapted in order to be less sensitive to this problem.
- calibration of NIR detectors: The calibration of channels 7 and 8 is still not optimal. Affecting the retrieval of the NIR species (CO, CH_4, N_2O, CO_2, H_2O) most are:
  - a light leak in Channel 7, causing stray light from outside the instrument to fall directly onto the detector. The problem is currently under investigation;
  - a changing "slit function", caused by a changing ice layer on the detectors. Although the ice is on average slowly disappearing from the instrument thanks to regular heating up of the detectors (see decontamination periods in Fig. 1), ice still builds up on the detectors when they are cooled after a decontamination. The line broadening of the incoming light caused by the ice layer has a variable shape. The problem is currently being analysed.
  - a thermal contribution to the dark current, changing along an orbit. The effect is understood, and a solution is currently being tested for implementation in the operational processor.

  The ice layer also causes a reduced signal throughput, making the retrieval of the NIR products more difficult. Since the ice is on average slowly disappearing from the instrument, because of the regular decontamination, this is expected to become less of a problem in the future. For H_2O retrieval scientific institutes now concentrate on the visible wavelength region to avoid the calibration problems in channels 7 and 8.

Although there are a number of other identified calibration problems, we do not list them in detail here, because they either have a minor effect on the current level 2 products, or their effect on level 2 products is still uncertain, because they are dominated by the problems listed above. The SCIAMACHY Calibration Tiger Team and the SCIAMACHY Quality Assurance Team (SQUAT) will track all open issues and make sure that they are communicated to the Agencies, the SCIAMACHY Science Advisory Group, and the Processor Teams.

Some of the known level 1 problems have been dealt with in an experimental scientific product from SRON, the so-called 'patched level 1b'.[2] Additionally, all groups working on non-operational retrievals are dealing internally with the calibration problems effecting their products.

[2] Details can be found on the web site of R. Van Hees: http://www.sron.nl/~hees/SciaDC/sron_patch_1b/index.html

2.1 Reflectance validation

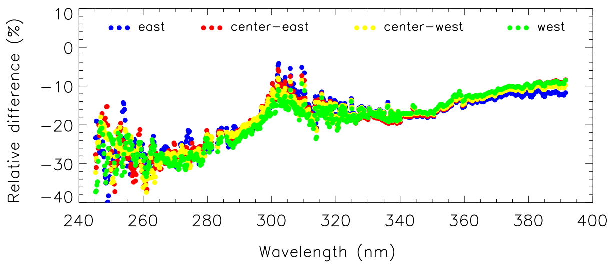

Figure 2. Relative difference between the reflectance measured by SCIAMACHY and that of simulated model data, for the cloud-free Sahara state of orbit 2509. Different colours are used to distinguish between four different viewing directions. Picture from Tilstra et al. (2004).

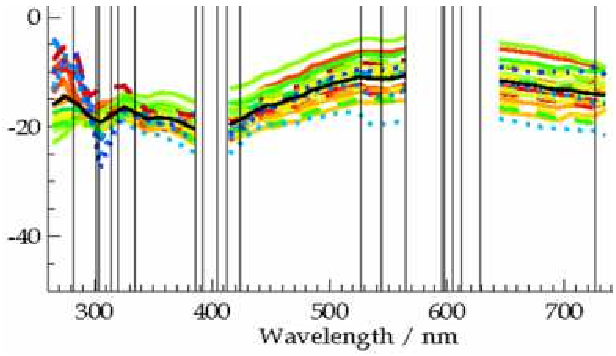

Figure 3. Relative difference between the reflectance measured by SCIAMACHY and that of GOME. Courtesy R. Siddans, RAL.

Figs. 2 and 3 show comparisons of the SCIAMACHY reflectance with a model and with GOME reflectance respectively. The offsets in nadir reflectance are 15-25% for channels 1 to 5, unknown for channel 6, and variable, due to the variable ice layer, for channels 7 and 8. Correction factors for the radiometric calibration (irradiance, radiance and reflectance) derived from on-ground and in-flight data (e.g., Tilstra et al. (2004), Acarreta et al. (2004)) lead to significant improvements. Limb reflectance is not validated yet. It is expected that limb reflectance will have several problems since some of the identified calibration issues will have an effect on limb radiance as well.

More details on the validation of SCIAMACHY reflectance can be found in Acarreta et al. (2004) and Tilstra et al. (2004).

3. PRODUCTS RETRIEVED FROM NADIR UV/VIS

3.1 O_3 columns

The current NRT O_3 column (software version 5.01) has improved with respect to December 2002 (version 3.53). It seems to be comparable with (but not equal to) the

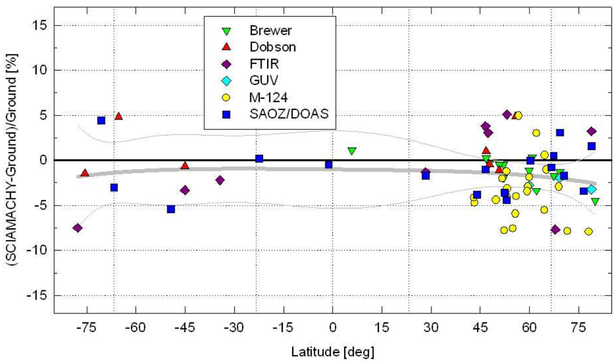

Figure 4. Mean percentage relative difference between the operational SCIAMACHY total O_3 column and ground-based total ozone column at approximately 60 stations, from August through November 2002, displayed as a function of latitude. Picture from Lambert et al. (2004a).

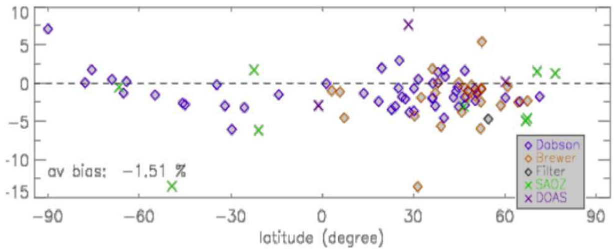

Figure 5. Comparison of the mean relative difference between SCIAMACHY ozone columns, retrieved at KNMI, and ground-based observations, (SCIAMACHY-Ground-based)/SCIAMACHY, as a function of latitude. Courtesy E. Brinksma, KNMI.

O_3 column from the previous operational GOME Data Processor (GDP) versions 2.x. The agreement to ground-based networks and satellite measurements falls within the 2-10% range (see Figs. 4 and 6). On a global average SCIAMACHY NRT O_3 underestimates correlative data by a few percent. Ground-based comparisons confirm the presence of errors inherited from GDP 2.x: the deviation of SCIAMACHY from ground-based data depends on the solar zenith angle (8-10% systematic underestimation beyond 75°), season, and viewing angle (2%). The apparent absence of dependence on the latitude is likely an artifact arising from compensating errors related to the Ring effect, the atmospheric profiles database and wavelength used for the AMF calculation, and the absorption cross-sections. On the other hand, an unexpected dependence on the fractional cloud cover is found at about one third of the stations: the ozone column increases linearly with the cloud fraction by 5-10% from cloud-free scenes to fully cloudy scans. A main difference with GDP 2.x (which did not show such a significant cloud dependence) is that SCIAMACHY NRT cloud fractions are derived with the Optical Cloud Recognition Algorithm (OCRA), while GDP 2.x are retrieved from the oxygen A absorption band around 760 nm with the Initial Cloud Fitting Algorithm (ICFA).

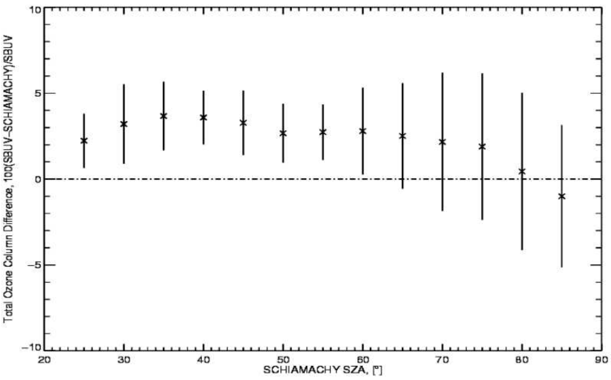

Figure 6. Comparison of operational SCIAMACHY total ozone column with SBUV/2. Plotted is the relative difference 100·*(SBUV-SCIAMACHY)/SBUV in % as a function of solar zenith angle, which is highly correlated with latitude. Courtesy E. Hilsenrath, NASA-GSFC.*

The Air Mass Factor (AMF) jumps in the SCIAMACHY Processor version 4.00, seen in the beginning of 2003 by BIRA and KNMI, could not be checked for the current processor version, since no data for 2003 was available.

While vertical columns look realistic, NRT slant columns show systematic offsets of up to 10% near the poles, when compared to independent retrievals at BIRA and KNMI. At high latitudes, thus at large solar zenith angles, errors on the slant column (SCIAMACHY NRT errors linked to the cross-sections and known errors of GDP 2.x linked to the Ring effect) and known errors on the AMF partly cancel.

The scientific products from KNMI and BIRA have a worldwide average bias of 1-1.5% , and a RMS of about 5% (see Fig. 5). The KNMI product has a cloud fraction dependence of 2-2.5%.

More details on the validation results for SCIAMACHY O_3 columns can be found in Lambert et al. (2004a), Hilsenrath et al. (2004), Eskes and Dethof (2004), Blumenstock et al. (2004), and Kopp et al. (2004).

3.2 NO_2 columns

The current NRT NO2 column (software version 5.01) has significantly improved with respect to December 2002 (version 3.53). Ground-based comparisons at stations representative of clean stratospheric conditions conclude to a good agreement of a few times 10^{14} molec/cm^2 in Southern winter-spring and Northern summer. A major concern is the systematic bias observed in the Arctic where the good agreement in summertime degrades in fall, SCIAMACHY reporting too high values by up to $1.5 \cdot 10^{15}$ molec/cm^2 (see Fig. 7). The current data sets are too limited to verify whether this season-dependent overestimation exists also in the Southern Hemisphere.

Over polluted areas, larger deviations are observed with ground-based columns while comparisons with GOME

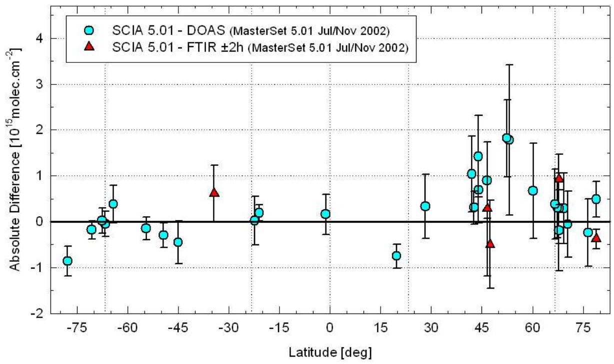

Figure 7. Meridian variation of the mean absolute difference between the operational SCIAMACHY NO_2 columns and NO_2 columns measured by NDSC ground-based spectrometers between July and November 2002. Picture from Lambert et al. (2004b)

GDP 3.0 columns yield reasonable agreement. This reflects the difference in sensitivity to the troposphere. The difference between SCIAMACHY total columns and ground-based stratospheric columns seems to follow the expected seasonal variation of tropospheric NO2. Nevertheless, at the time being it is hazardous to conclude whether this behaviour is not partly due to the same overestimation problem as reported in the Arctic. Quantitative validation of tropospheric NO2 is also premature due to the lack of correlative measurements in the troposphere.

Preliminary SCIAMACHY NO2 columns generated at independent scientific institutes (BIRA, IFE, IUP-Heid, KNMI, SAO) have also been tested against ground-based network data. Despite the premature character of this study, first results are encouraging: all data sets capture major geophysical signals appropriately. As expected, differences in the retrieval settings and in the simplifications adopted for this first exercise can produce differences between the data products. Those differences raise interesting issues to be addressed in future developments of both the operational and research processors.

More details on the validation results for SCIAMACHY NO_2 columns can be found in Lambert et al. (2004b), Blumenstock et al. (2004), Richter et al. (2004), Sussmann et al. (2004) and Kostadinov et al. (2004).

3.3 BrO columns

NRT BrO slant columns (version 5.01) agree well with ground-based DOAS measurements, with GOME satellite measurements and with independent SCIAMACHY retrievals (all made at BIRA, IFE and IUP-Heid) within 20% for moderate and large slant columns. In summer, for slant columns smaller than $1.5 \cdot 10^{14}$ molec/cm^2, the NRT product reports systematically higher values by 20 to 100% (see Fig. 8). First comparisons of independent retrievals with ground-based and GOME data are encouraging. As the difficult behaviour of BrO requires advanced comparison techniques, detailed quantitative validation of BrO columns is clearly a challenging task to be

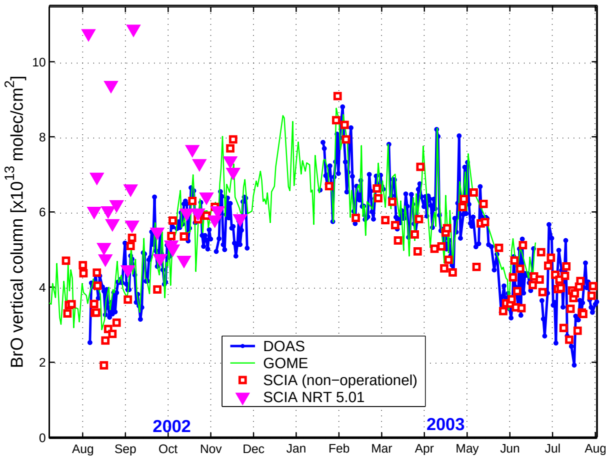

Figure 8. Comparison between BrO vertical columns independently derived from GOME, ground-based and SCIAMACHY observations above Harestua (Norway, 60deg N). Non-operational and operational SCIAMACHY evaluations agree well during autumn and winter, while summer values are significantly overestimated by the operational processor during summer. Courtesy M. van Roozendael, BIRA-IASB.

envisaged on the longer-term.

3.4 SO_2 columns

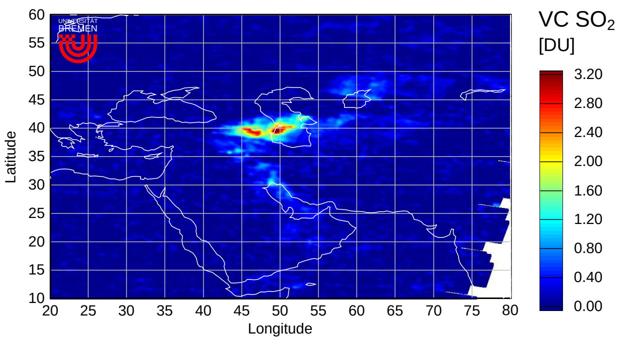

Figure 9. A tropospheric SO_2 plume observed by SCIAMACHY between 26 June and 25 July 2003, after a fire in a sulphur plant in Iraq. Courtesy A. Richter, University of Bremen.

Two algorithms for the retrieval of SO_2 total columns from SCIAMACHY nadir measurements are available, developed by BIRA and IFE. The algorithms are both able to detect volcanic emissions and strong pollution events (see Fig. 9). Comparison with results from applying the same methods to SCIAMACHY's precursor instrument GOME show good agreement. Nevertheless, a fully independent validation has not yet been performed because of the lack of independent measurements during strong emission events. GOME results are not fully independent, because they are basically retrieved from the same algorithms.

More details on the validation results for SCIAMACHY SO_2 columns can be found in Bramstedt et al. (2004).

3.5 OClO columns

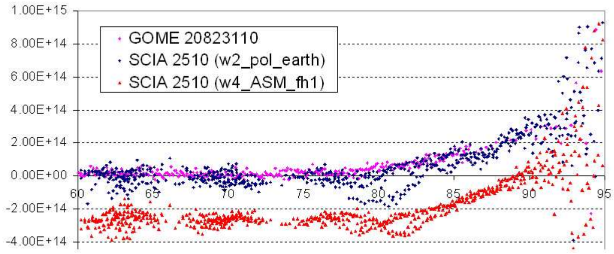

Figure 10. Influence of different Fraunhofer spectra on the OClO slant column densities (y-axis, molec/cm^2) derived from SCIAMACHY observations (scientific algorithm from the University of Heidelberg, SCIAMACHY orbit 2510), as a function of solar zenith angle (x-axis). The polar vortex in this diagram is located around a solar zenith angle of 79°, as can be seen from the increasing OClO values. The dark blue symbols indicate the use of a polarisation sensitivity spectrum in the spectral fit, to account for errors in the polarisation correction of the spectrum. The red values are retrieved without such a polarisation sensitivity spectrum. Results from simultaneous GOME observations are also included in the diagram (magenta). Picture from Wagner et al. (2004).

Two algorithms for the retrieval of OClO slant columns are available, developed by IFE and IUP-Heidelberg. Comparisons have been performed between the OClO slant column densities retrieved from GOME and SCIAMACHY (Wagner et al. (2004)). From Fig. 10 it can be seen that the inclusion of a polarisation sensitivity spectrum in the spectral fit, to account for errors in the polarisation correction of the spectrum, improves the OClO slant column considerably. The remaining slightly higher scatter in the SCIAMACHY slant column densities can be reduced when including additional empirical correction spectra in the fit (A. Richter, private communication).

More details on the validation of SCIAMACHY OClO slant columns can be found in Wagner et al. (2004).

3.6 H_2O columns

Four algorithms are currently being developed for the retrieval of water vapour columns. Currently two of these algorithms deliver scientific products available for validation. The AMC-DOAS algorithm from IFE compares reasonable with water vapour sondes, as can be seen from Fig. 11. There is an average offset of about 10% (SCIAMACHY being too low), and a scatter of approximately 30-40%. The SSP algorithm from MPI has an offset of 20 to 25% when compared to ground-based measurements. It is expected that the results can be improved after forthcoming significant improvements of the quality of the level 1 calibrated SCIAMACHY data set.

More details on the validation of SCIAMACHY H_2O columns can be found in Timmermans et al. (2004).

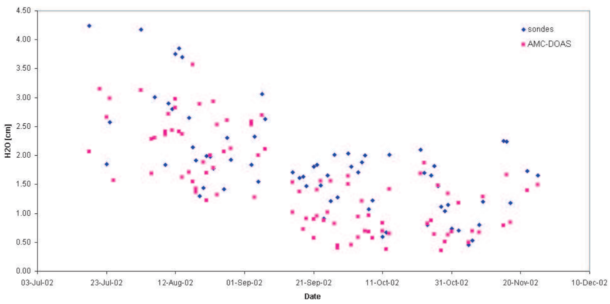

Figure 11. SCIAMACHY water vapour columns retrieved by IFE with the AMC-DOAS algorithm (magenta squares), and integrated sonde water vapour measurements (blue diamonds) for the Legionowo station (52.4°N, 21.0°E) as a function of the date in 2002. Picture from Timmermans et al. (2004)

3.7 Clouds

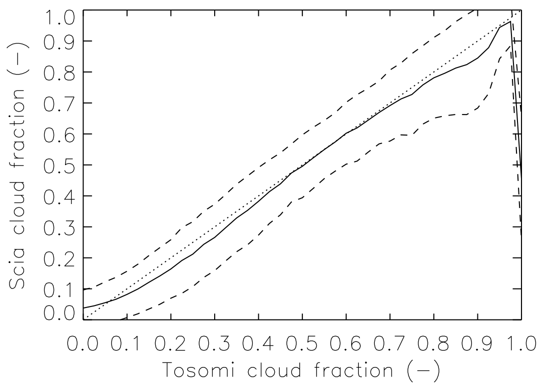

Figure 12. Comparison between the operational cloud fraction ('Scia cloud fraction', retrieved with the OCRA algorithm) and a non-operational cloud fraction ('Tosomi cloud fraction', retrieved with the FRESCO algorithm), for the complete SCIAMACHY validation reference set. The discrepancy at a cloud fraction of 1 is due to a known FRESCO feature. This algorithm does not retrieve cloud fractions over regions with continuous snow or ice, but assumes a value of 1. Picture from Fournier et al. (2004)

The operational SCIAMACHY cloud fraction correlates very good with the cloud fraction retrieved with FRESCO (KNMI), as can be seen in Fig. 12. The standard deviation of the difference is 0.1. The operational cloud fraction has a viewing-angle dependant error caused by a wrong formula for the calculation of the reflectance. The FRESCO algorithm is quite sensitive to errors in the reflectance. Therefore, a constant correction factor has been applied to the spectrum before the cloud fraction retrieval. FRESCO has been validated for GOME retrievals, but not yet for SCIAMACHY. The FRESCO algorithm is known to slightly overestimate the cloud fraction over regions with high albedo (like the Sahara). Another cloud fraction algorithm, HICRU, is being de-

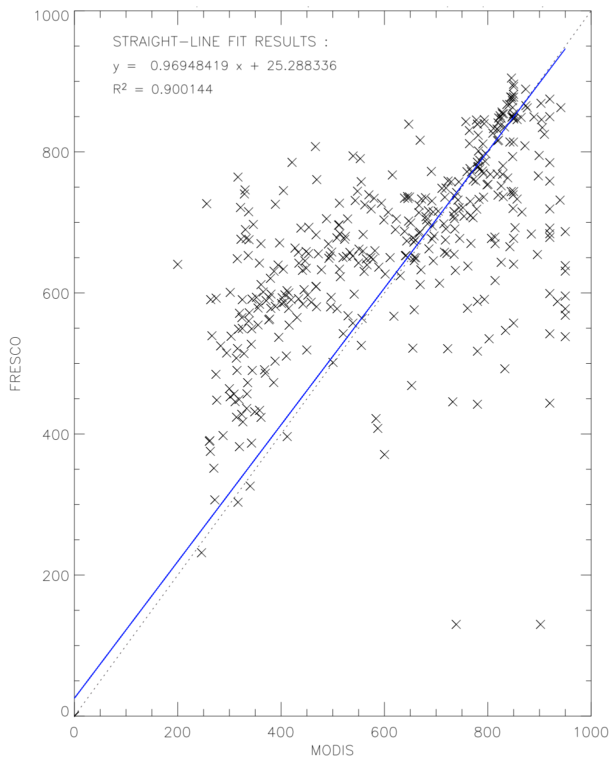

Figure 13. Comparison of cloud top pressure derived from FRESCO using SCIAMACHY data with MODIS co-located values for the orbit 2510 (August 23, 2002). The dotted line is the one-to-one agreement while the solid line is the best fit produced by a regression analysis. Picture from Fournier et al. (2004).

veloped at IUP-Heidelberg. First comparisons between GOME and SCIAMACHY retrievals with HICRU are promising.

The cloud-top pressure is not (yet) retrieved in the operational NRT processor. The cloud-top pressure in the NRT product is a climatological value (ISCCP), used for the ozone retrieval. The FRESCO cloud-top pressures were compared to MODIS (see Fig. 13). A RMS difference of about 100 hPa was found. Another promising cloud-top pressure algorithm, SACURA, is currently being developed at IFE.

More details on the validation of SCIAMACHY cloud products can be found in Fournier et al. (2004).

3.8 Aerosol

The aerosol algorithms are very sensitive to errors in the reflectance. With the current known errors, see Sect. 2.1, validation of the operational Absorbing Aerosol Index is not possible. The scientific retrievals of the AAI at KNMI and of the Aerosol Optical Thickness (AOT) at IFE have been performed after correcting the reflectance with empirical correction factors. The SCIAMACHY AAI, retrieved at KNMI, compares good to TOMS AAI (see De Graaf et al. (2004)). The SCIAMACHY AOT, retrieved

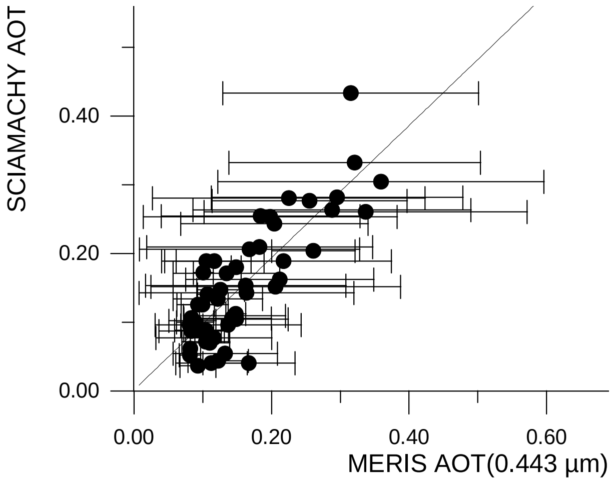

Figure 14. The aerosol optical thickness for 0.443 µm channel, retrieved from MERIS and SCIAMACHY for colocated pixels over the Baltic Sea. Picture from Von Hoyningen-Huene (2004).

at IFE, shows a reasonable comparison with MERIS, as can be seen in Fig. 14.

More details on the validation of SCIAMACHY aerosol products can be found in Von Hoyningen-Huene (2004) and De Graaf et al. (2004).

4. PRODUCTS RETRIEVED FROM NADIR NIR

4.1 CH_4 columns

Two scientific algorithms for CH_4 columns, WFM-DOAS from IFE and IMLM from SRON, have been compared to the TM3 model, ground-based data, and satellites. The retrieval and validation has been performed on cloud-free pixels. Monthly mean values show an offset with respect to the TM3 model of up to 5%; individual ground-based comparisons are mostly within 20%.

More details on the validation results for SCIAMACHY CH_4 columns can be found in Mazière et al. (2004), Gloudemans et al. (2004), Camy-Peyret et al. (2004), and Sussmann et al. (2004).

4.2 CO columns

Two scientific algorithms for CO columns, WFM-DOAS from IFE and IMLM from SRON (see Fig. 15), have been compared to ground-based data and the TM3 model. The retrieval and validation have been performed on cloud-free pixels. Individual ground-based comparisons are mostly within 40%.

More details on the validation results for SCIAMACHY CO columns can be found in Mazière et al. (2004), Gloudemans et al. (2004), Camy-Peyret et al. (2004), and Sussmann et al. (2004).

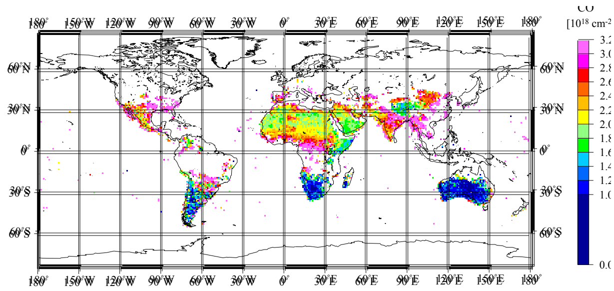

Figure 15. Monthly averaged CO total columns from the SRON retrieval algorithm IMLM for February 2004. Only cloud-free pixels with retrieval errors $< 1.5 \cdot 10^{18}$ molec/cm^2 have been included. Picture from Gloudemans et al. (2004).

4.3 N_2O columns

IFE retrieves N_2O columns with the WFM-DOAS algorithm. The validation has been performed on cloud-free pixels. Individual ground-based comparisons are mostly within 20%.

More details on the validation results for SCIAMACHY N_2O columns can be found in Mazière et al. (2004), Gloudemans et al. (2004), Camy-Peyret et al. (2004), and Sussmann et al. (2004).

4.4 CO2 columns

SCIAMACHY CO_2 columns are retrieved by IFE with the WFM-DOAS algorithm. The values look reasonable, as was shown in a poster by T. Warnecke.

5. PRODUCTS RETRIEVED FROM LIMB UV/VIS

5.1 O_3 profiles

The operational SCIAMACHY ozone profile is retrieved with the Off-Line (OL) processor at DLR (version 2.1). The OL processor is not yet fully operational, but 383 states between July and December 2002 were processed for validation. Also for the ozone profiles generated by IFE a preliminary validation has been performed. Despite inaccuracies due to a cyclic drift in pointing of about 1.5 km, SCIAMACHY ozone profiles agree to within about 10% to ground-based, and to within 30% to satellite data.

More details on the validation results for SCIAMACHY ozone profiles can be found in Brinksma et al. (2004), Blumenstock et al. (2004), Kuttippurath et al. (2004), and Amekudzi et al. (2004).

5.2 NO_2 profiles

The operational OL NO_2 profile and the scientific retrievals from IFE and SAO have been compared to HALOE, SAGE II, and ground-based measurements.

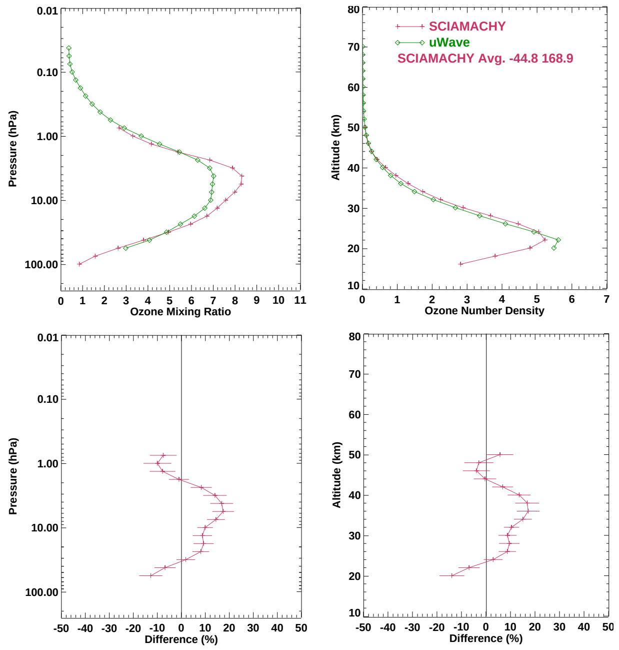

Figure 16. SCIAMACHY operational ozone profile compared with microwave data over Lauder, New Zealand (45°S, 170°E) by I. Boyd, NIWA. Average over 17 co-incidences between July and November 2002. Results are given in units of mixing ratio (left panels) and number density (right panels). Relative differences are (SCIAMACHY-microwave)/mean in %. Picture from Brinksma et al. (2004).

The OL NO_2 profile is about 50% higher than HALOE between 25 and 40 km. In 10% of the cases the OL NO_2 profiles look very unrealistic.

The IFE profiles are within 15% of the HALOE profiles between 22 and 33 km, and 10-35% lower than SAGE II. Both IFE and SAO NO_2 profiles show a reasonable to good agreement with SAOZ balloon profiles (see Fig. 17). It is clear that a photochemical correction is needed when comparing NO_2 profiles obtained at different times.

More details on the validation results for SCIAMACHY NO_2 profiles can be found in Von Savigny et al. (2004).

5.3 BrO profiles

BrO profiles are retrieved by SAO and IFE. Only very few comparisons with balloon data could be made (see Fig. 18). The results look already promising, although a major discrepancy is seen below 20 km. It is clear that a photochemical correction is needed when comparing BrO profiles obtained at different times (not yet done in Fig. 18).

6. RECOMMENDATIONS

The main recommendations collected from the various presentations are:

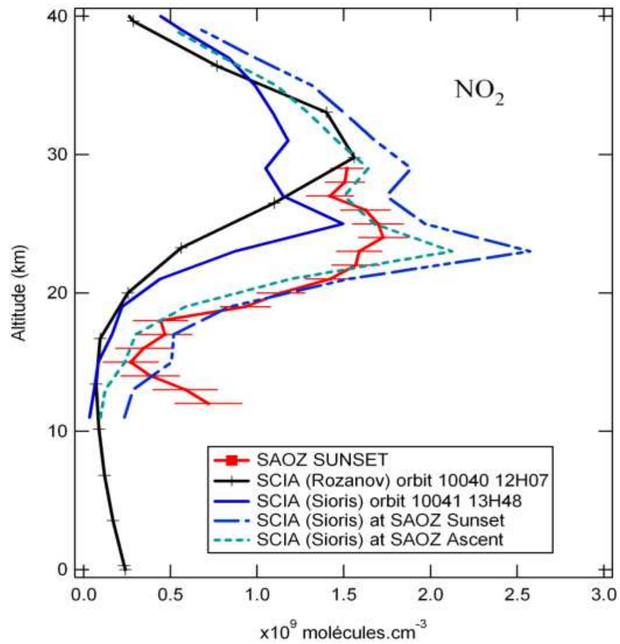

Figure 17. NO_2 profiles retrieved by IFE (black) and SAO (blue solid line) from two different states close to a SAOZ balloon profile (red). The dashed profiles are the same as the SAO profile, but now with a photochemical correction applied to account for time differences between the SCIAMACHY and the balloon profile. Courtesy F. Goutail, CNRS/IPSL.

- The operational level 1b-2 processor should include known improvements from the scientific retrievals.[3]
- Operational DOAS algorithms should be improved to be consistent with current and future GOME operational algorithms to create a consistent data set.
- Further improvements of the level 0-1b processor are urgently needed and should be implemented as soon as possible. The issues most hampering the level 1b to 2 retrieval are: spurious polarisation features in the UV, a wrong absolute radiometric calibration and several issues related to the calibration of the near-infrared channels 7 and 8.
- A well defined validation reference set should be processed completely after each processor upgrade, before reprocessing the complete mission.
- Product user manuals should be written, including detailed format and content description.
- Auxiliary files should be available[4] and well documented.
- All changes in processor algorithm and initialisation files should be well documented and announced well in advance whenever possible.

[3] Product developers should formulate Processor Change Requests (PCRs) for this and send them to ESA (eohelp@esa.int) and DLR-Bonn (christian.chlebek@dlr.de).

[4] The SCIAMACHY auxiliary files are now available on the Envisat website: http://envisat.esa.int/services/auxiliary_data/sciamachy

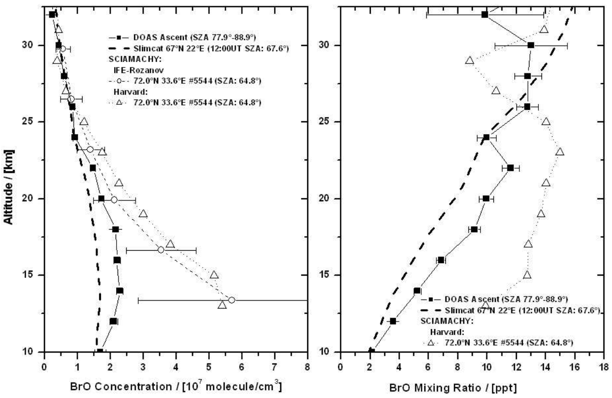

Figure 18. BrO profiles observed with a DOAS balloon (black squares) compared to SCIAMACHY BrO profiles retrieved by IFE (circles) and SAO (triangles). Courtesy K. Pfeilsticker, IUP-Heidelberg.

7. CONCLUSIONS

Many SCIAMACHY products are now available for research, both operational and non-operational. Systematic offset and RMS values could already be attached to a number of columns and profiles, sometimes for several geophysical conditions. In general, the SCIAMACHY products have improved considerably since the First Envisat Validation Workshop in December 2002, both in number and in quality. All validation results are however still preliminary in the sense that: a) data sets from longer periods with better sampling are necessary to detect seasonally varying errors and other medium-scale effects; b) not all available validation sources were properly used, due to lack of time; and c) comparison results reported here do not always reflect the expected final quality of the products as some of the SCIAMACHY data products are not generated with state-of-the-art processors (due e.g. to delays in the delivery of accurate level-1 data). Several recommendations to the agencies have been formulated in Sect. 6. The recommendations are on urgently needed processor improvements and on the availability of data and documentation. Detailed information about the results presented here are available in the SCIAMACHY related papers in these proceedings. Note that they may differ, because the results from this summary paper are mainly based on the presentations, while the papers in these proceedings have in some cases evolved considerably since their presentation at the ACVE-2. The conclusions in the separate SCIAMACHY product papers are therefore more up-to-date.

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