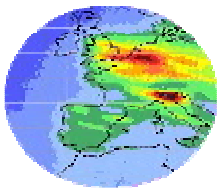

SCIAMACHY CO Retrieval Intercomparison Workshop

held at SRON National Institute for Space Research, Utrecht, the Netherlands on April 14, 2005

Meeting report

Prepared by Annemieke Gloudemans

1. Opening and Aim of the Workshop.

The focus of this "SCIAMACHY CO Retrieval Intercomparison Workshop" is to have (at least an initial) in depth discussion between the various scientific groups working on CO total column retrieval from SCIAMACHY's near-infrared spectra (mainly Heidelberg, SRON, Bremen).

Results from one SCIAMACHY orbit (October 27, 2003) will be discussed in detail starting with the spectra, the fits and the retrieved CO total columns. The main goal is to improve the existing algorithms, in order to obtain more accurate CO total columns from SCIAMACHY. The current accuracy of the CO total column retrievals is within ~30-40% for individual ground pixels, but an accuracy of ~10-15% is required to obtain better emission estimates from SCIAMACHY data.

2. Scientific Presentations

- Intercomparison of SCIAMACHY CO scientific retrieval algorithms: University of Bremen analysis - *Rüdiger de Beek (IUP-Bremen)*
- Satellite cartography of atmospheric CO - *Christian Frankenberg (IUP-Heidelberg)*
- CO comparisons IMAP, IMLM, WFM-DOAS - *Annemieke Gloudemans (SRON, Utrecht)*
- Strict co-locations of SCIAMACHY CO and ground-based FTIR - *Bart Dils (BIRA)*

3. Discussion Points

The differences between the three retrieval algorithms have been discussed and a table of these differences has been compiled. For each difference the possible impact on the retrieved CO total column has been discussed and is indicated in the table below. The impact is not always clear, as for example for the solar spectrum used, and thus needs to be investigated.

Table 1: Comparison of three different algorithms used for the retrieval of CO total columns from SCIAMACHY measurements. The Table below gives the status as off April 14, 2005 and is only relevant for CO total column retrievals from SCIAMACHY's near-infrared channel 8!

Note that many changes are planned (see also the Table below) and thus that this table will probably be outdated in a few months time. A new version of this table will hopefully be provided after next meeting in November 2005.

	IMAP	IMLM	WFM-DOAS	Possible impact[1]
Retrieval window (nm)	2324.2-2334.9	2321.3-2333.7	2359 - 2370 (a) * 2324 - 2335 (b) *	+
HITRAN version	2004	2000 + 2001 updates	2000 + 2003 updates	+
Pixel mask	Fixed mask (CF) +Stdev dark (per orbit)	Time-dependent mask Kleipool (per orbit)	(a): SRON (v2002) + manually modifications (b): Same as IMAP	++
Dark correction per orbit	Yes, based on level 1b mean (1 integration time) #	Yes (from Kleipool, fit all integration times) #	Yes, based on level1b mean (using corresponding Pixel Exposure Time (PET) #	Included by all
Variation dark over orbit	Preliminary, offset fit parameter (spectrum)	Yes	(a) No (b) Plan, divide by CH_4	+
Slit function correction due to ice layer	No	Yes	(a) No (b) Plan, divide by CH_4	++
Non-linearity	Yes	No	Yes	?
Scaling factor for retrieved total columns	No	No	(a) Yes (b) No	+
Normalization to surface pressure	No	No	No	-
Radiance sensitivity (effect on residuals)	No	Yes	(a) Yes (b) No	+
PPG	Yes (from level 1b)	Yes, fixed **	Yes (from level 1b)	-
Temperature profile fit	CH_4,H_2O: yes. Fit diff. climatology	No, but new data includes ECMWF T-profile	Fit temperature. weighting functions	+
Solar spectrum	Special one from Johannes Frerick	Special one from Johannes Frerick	Special one from Johannes Frerick	+/?
Pixel weighting	Yes, based on Stdev of dark and absolute signal	Yes, noise related	No	?
H_2O continuum from database/literature	No	No, offset fitted	No	?
Data filter	Residual <1.5%, errors (noise) <40% of CO total column	Noise-related error <1.5x10^{18} molec/cm^{-2}	Estimated fit error (based on residual) < 60%	+/-
Preferred cloud filter (cloud fraction, cloud top height)	CO/CH_4, threshold CH_4 Planned: HICRU	Threshold cloud-free PMD B,C,D Planned:CO/CH_4, HICRU	(a)Threshold cloud-free, PMD A (b) identification/correction via CH_4	+
Straylight	No	No	(a) Yes (from level 1b) (b) No	?
Doppler shift	Yes, shift is fitted	No, optimised and fixed	Yes, shift is fitted	?

[1] - not significant; +/- marginally significant; + significant; ++ very significant; ? unknown

* (a) refers to WFM-DOAS version 0.4
(b) refers to CO intercomparison efforts (preliminary) and further analysis

Comparison of the two different methods shows that they compare well

** Comparison of PPG from level 1b and the fixed PPG shows only marginal differences for CO retrievals.

4. Conclusions and Recommendations

The differences between the three retrieval algorithms have been identified and an inventory of important SCIAMACHY CO retrieval parameters has been made. It has been agreed that for each algorithm the influence of these specific retrieval parameters shall be investigated and the algorithms improved when necessary. After these improvements, the SCIAMACHY orbit discussed at this meeting shall be processed again by all three algorithms. However, due to limited resources, it was not possible to agree upon a clear deadline for this activity within the next couple of months. It is recommended that the latest results shall be discussed during another SCIAMACHY CO retrieval comparison workshop, which is planned around November 2005, again in conjunction with the EVERGREEN meeting to minimize travel(costs) for all participants.

5. Close

Acknowledments:

The work performed for this publication is (partly) financed by the Netherlands Agency for Aerospace Programmes (NIVR), BMBF via DLR-Bonn (Grants 50EE0027 and 50EE9901), GSF/PT-UKF (Grant 07UFE12/8), the University and state of Bremen, and the European Commission (Fifth Framework Programme on Energy, Environment, and Sustainable Development, Contract no. EVG-1-CT-2002-00079, project EVERGREEN).

Appendix 1 Participants and Affiliations

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Appendix 2 Statement of Workshop Expenses

	Meeting Costs (room, facilities, services etc.)	7 x lunch: x 4,5 euro = 31,50 euro
	Personnel Costs, if any	0
	Participants Travel costs Indicate the number of people it is proposed to support and at what level	3x 1 night at a hotel for participants 1,2, and 6: 3x 79 euro = 237 euro 1x travel to SRON by taxi for participant 8: 253,70
	Other Expenses	0
	Total	522,20 euro

Appendix 3 Workshop Programme

Time: 14 April 2005, 9:00h - 12:00h

Agenda:

Start 9:00h

1. Opening and welcome

2. Announcements concerning AT2 funding

(incl. filling out the travel forms)

3. Presentations :

3.1. Uni Bremen analysis (Michael Buchwitz/Rüdiger de Beek)

3.2. SRON analysis (Annemieke Gloudemans)

3.3. Uni Heidelberg analysis (Christian Frankenberg)

3.4. BIRA/IASB validation with ground-based FTIR (Bart Dils)

4. Discussion

5. Conclusions

6. Closing (12:00h)

12:00-13:00 : lunch (will be provided)

13:00-13:30: travel from SRON to KNMI (for EVERGREEN PM3 meeting)

Appendix 4 Individual Scientific Contributions, if appropriate

SCIAMACHY CO intercomparison: University of Bremen analysis

Michael Buchwitz, Rüdiger de Beek
21 April 2005

Currently, version 0.4 of the University of Bremen WFM-DOAS (or WFMD) algorithm is used to retrieve CO columns from SCIAMACHY nadir spectra (see Buchwitz et al., 2004, 2005 for details).

Although WFMD v0.4 CO columns are promising, a number of problems have been identified which we would like to solve for the next version of the algorithm:

- The WFM-DOAS v0.4 CO columns are scaled with a constant factor
- Too many pixels are rejected because of too conservative cloud filtering
- In certain months the interhemispheric difference seems to be underestimated

The goal of our activity was to learn from a detailed comparison of our own results with the results from the other groups. For this comparison we have agreed upon a reference orbit which is shown in Fig. 1. This orbit has been selected because it covers an interesting scene (e.g., plumes of CO due to biomass burning, lots of cloud free pixels, high variability of surface elevation surface type, and good overlap with MOPITT). Figure 1 shows the WFM-DOAS v0.4 CO columns.

We have performed a detailed comparison with the results provided by the other groups (comparison of spectra, fit residuals, CO columns etc.). The CO columns, for example, are shown in Fig. 2. As can be seen, there is quite some difference between the results of the various groups and also with respect to MOPITT.

Based on all available data we have done a number of investigations in order to improve our data product. When applying WFM-DOAS to the spectral fitting window also used by the Heidelberg group, we obtain reasonable CO without the need for a scaling factor. Also the quality of the spectral fits is better compared to our default spectral window. We found the fit can be improved when not switching on certain calibration steps (e.g., the application of the radiance sensitivity) when generating the SCIAMACHY Level 1c files.

We will use what we have learned from this comparison when generating an improved WFM-DOAS CO product which will probably be called version 0.5. The version 0.5 columns will be absolute columns, i.e., unscaled columns. We also plan to solve the cloud problem mentioned above (and also the ice problem not discussed here) by dividing the retrieved CO column by the simultaneously measured methane column.

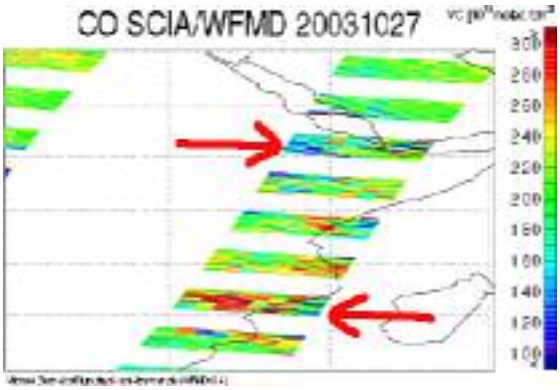

Figure 1: Reference orbit 8663 from 27 October 2003 used for the CO comparison. Indicated by the two red arrows are the two reference states with „low“ and „high“ CO columns. For details see Buchwitz et al., 2004.

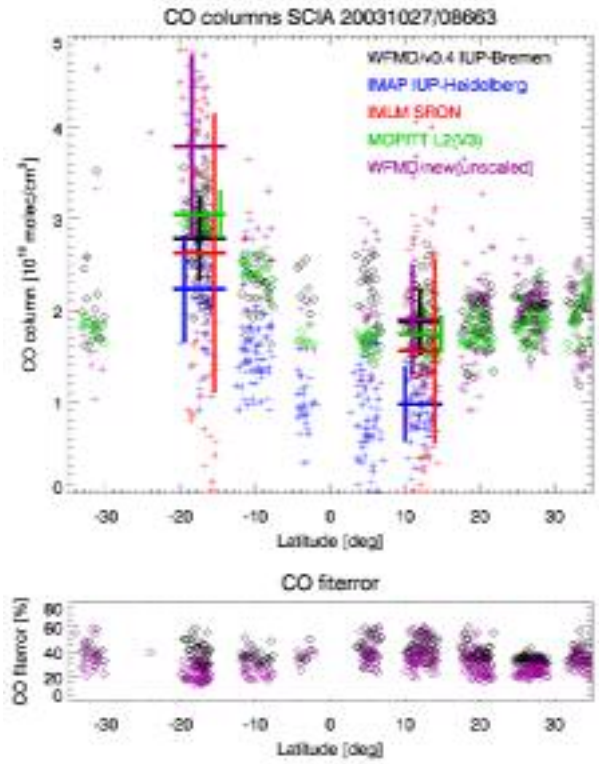

Figure 2: Top panel: Various CO column data products derived from SCIAMACHY orbit 8663 (see Fig. 1). For comparison the CO column data product of MOPITT is shown in green. The horizontal lines show latitudinal averages and the vertical lines the corresponding standard deviations. Bottom panel: CO fit error for WFMD v0.4 CO (black) and for our new CO product derived from a different spectral window.

References:

[Buchwitz et al., 2004] Buchwitz, M., R. de Beek, K. Bramstedt, S. Noël, H. Bovensmann, and J. P. Burrows, Global carbon monoxide as retrieved from SCIAMACHY by WFM-DOS, Atmos. Chem. Phys., 4, 1954-1960, 2004.

[Buchwitz et al., 2005] Buchwitz, M., R. de Beek, S. Noël, J. P. Burrows, H. Bovensmann, H. Bremer, P. Bergamaschi, S. Körner, M. Heimann, Carbon monoxide, methane and carbon dioxide columns retrieved from SCIAMACHY by WFM-DOAS: year 2003 initial data set, Atmos. Chem. Phys. Discuss., 5, 1943-1971, 2005. *(ACP Special Issue: Geophysical Validation of SCIAMACHY 2002-2004)*

SCIAMACHY CO intercomparison: SRON analysis

Annemieke Gloudemans, Hans Schrijver
25 April 2005

For the comparisons presented at this workshop version 5.5 of the SRON retrieval algorithm IMLM has been used to retrieve CO total columns from SCIAMACHY near-infrared nadir spectra (see Gloudemans et al. 2005 for details).

Like the WFM-DOAS and IMAP CO columns, the IMLM v5.5 columns are promising, but some improvements will be made for the next version.

In addition to the analyses performed by the University of Bremen, SRON has performed some additional comparisons ranging from the comparison of the cloud algorithms used, to the actual retrieved total columns of CO and other species present in the wavelength region used for CO retrievals. Since these other species, H_2O and CH_4, may influence the retrieved CO total columns, it is important to also compare their values in a detailed analysis as performed for this workshop.

Also, a table was set up with a number of parameters that can possibly influence the retrieval of CO total columns from SCIAMACHY nadir spectra. The table was completed and extended during the workshop and is attached to this meeting report. It gives a nice summary of the most important differences between the three retrieval algorithms. It also indicates some planned changes/improvements for each algorithm.

References:

[Gloudemans et al. 2005] Gloudemans, A.M.S., Schrijver, H., Kleipool, Q., van den Broek, M.M.P., Straume, A.G., Lichtenberg, G., van Hees, R.M., Aben, I., Meirink, J.-F., The impact of SCIAMACHY near-infrared instrument calibration on CH_4 and CO total columns, Atmos. Chem. Phys. Discuss., 5, 1733-1770, 2005. *(ACP Special Issue: Geophysical Validation of SCIAMACHY 2002-2004)*

SCIAMACHY CO intercomparison: IUP-Heidelberg analysis

Christian Frankenberg, U. Platt. T. Wagner
7 May 2005

For the comparisons presented at this workshop version 1.1 of the Heidelberg retrieval algorithm IMAP has been used to retrieve CO total columns from SCIAMACHY near-infrared nadir spectra. In contrast to the previous version, the new HITRAN database (HITRAN04) has been applied.

The results of the IMAP algorithm look promising and seem to reflect the spatial patterns and seasonal variations of global CO abundances. However, retrieved columns seem to be persistently lower than total columns of CO derived from ground based measurements or MOPITT. The meeting gave important input on how to avoid this obvious bias: The applied slit function seems to be too narrow, thereby resulting in a negative bias of the retrieval.

For the future, it is planned to implement a time depenend slit function and to compare these results with the current version of the IMAP algorithm and the other retrieval algorithms from Bremen (WFM-DOAS) and SRON (IMLM). Further, the effect of the additional spectral calibrations such as the orbital variation of the dark current (see SRON analysis) will be analysed. Also in this respect, the meeting gave important information on possible calibration problems and their solutions of the different workgroups.

References:

Frankenberg, C., Platt, U. and Wagner, T., Retrieval of CO from SCIAMACHY onboard ENVISAT: detection of strongly polluted areas and seasonal patterns in global CO abundances, *Atmos. Chem. Phys. Discuss. (accepted for ACP)*, 4, 8425-8438, 2004

A Strict collocation comparison exercise between SCIAMACHY and ground-based FTIR network CO.

B. Dils, M. De Mazière, M. Buchwitz, R. De Beek, C. Frankenberg, A. Gloudemans, H. Schrijver, M. van den Broek, T. Blumenstock, P. Demoulin, P. Duchatelet, H. Fast, D. Griffith, N. Jones, T. Kerzenmacher, I. Kramer, E. Mahieu, J. Mellqvist, R. L. Mittermeier, J. Notholt, C. P. Rinsland, H. Schrijver, D. Smale, A. Strandberg, A. G. Straume, W. Stremme, K. Strong, R. Sussmann, J. Taylor, T. Wagner, T. Warneke, A. Wiacek, S. Wood

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In our recent article in ACPD (B.Dils et al.,2005 accepted for publication), we acquired a statistically sound comparison dataset by applying a course spatial collocation grid and applying a polynomial fitting procedure through the FTIR data. However, for this exercise we performed a very strict spatial and temporal collocation, namely
A. Only SCIAMACHY data which are cloudfree, and meet all the other error requirements as stated by the various retrieval groups, **B.** Only SCIAMACHY pixels which were measured over a ground based FTIR site, **C.** The measurement had to be performed within 1 (3 and 7 were performed as well) day(s) of the FTIR measurement (the latter are daily averages)

After the spatial collocation step we retain surprisingly few datapoints (over an entire 2003 period over all stations): WFM-DOAS: 9 SCIA pixels vs. 4752 in the large grid polynomial dataset; IMLM: 28 SCIA pixels vs. 8666 and IMAP: 13 SCIA pixels vs. 13186 in the large grid polynomial dataset. These datapoints, however few, are useful tools for the retrieval researchers to have a quick view on the impact of any further algorithm improvement. However, to draw any conclusions on the general quality of the algorithm, the dataset is simply too small. The still considerable differences between the FTIR and satellite datapoints do however indicate that the large variance as seen in the large collocation dataset as used in the ACPD paper is not merely due to the loose spatial collocation criteria.

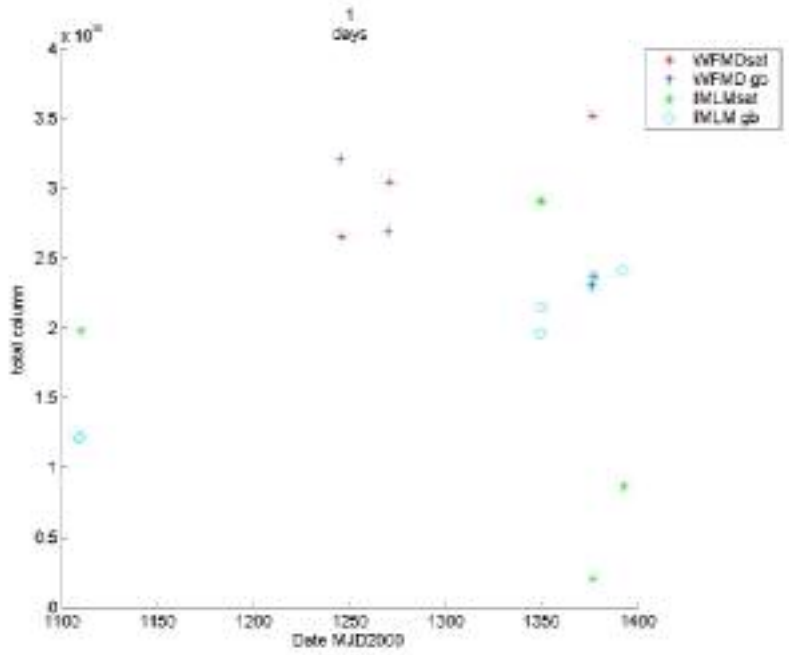

Fig 1: Overlapping SCIA data points within one day of a ground-based FTIR measurement