SCIAMACHY Absorbing Aerosol Index

Product Specification Document

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Document status sheet

Issue	Date	Page(s)	Modified Items / Reason for Change
0.1	17-08-2008	all	first draft version
0.2	16-11-2008	all	first revised version, valid for algorithm version 4.0
0.3	28-03-2009	all	updated Section 7
0.4	11-05-2009	all	minor changes in document text
1.0	27-01-2010	all	new version after major algorithm update (v4.1)
2.0	11-10-2011	all	new version after major algorithm update (v5.0)
2.1	07-06-2012	all	update after release of v5.1 data

Contents

1 Introduction

1.1 Document purpose and scope

This document is the Product Specification Document for the SC-AAI, the SCIAMACHY Scientific Absorbing Aerosol Index (AAI) developed at our institute. The aim of this PSD is to present to the reader the SC-AAI data we provide at the TEMIS website (http://www.temis.nl).

It is assumed that the reader has some basic knowledge of the SCIAMACHY instrument [1] and of the way it performs its nadir measurements. If needed, additional background information on the subject can be found in the SCIAMACHY level 0-1c processing ATBD [2].

1.2 Definition of viewing and solar angles

The sphere in Figure 1 defines, in a graphical way, the angles that are used to specify the viewing and solar directions of the incoming and outgoing radiation. An imaginary volume element, responsible for the scattering of incident sunlight, is located in the origin of the sphere. The solar direction is described by the solar zenith angle θ_0 and the solar azimuth angle ϕ_0. Likewise, the viewing direction is characterised by the viewing zenith angle θ and the viewing azimuth angle ϕ.

In this PSD we make use of a right-handed coordinate frame, meaning that $\phi - \phi_0$ as sketched in Figure 1 is positive. By doing this, we follow the same definition of ϕ and ϕ_0 adopted for official SCIAMACHY data. However, there is no real need to specify this sense of rotation, because the sign of the azimuth difference $\phi - \phi_0$ is not relevant. For completeness, we mention that the single scattering angle, following this definition of angles, is calculated from the following formula:

$$\cos\Theta = -\cos\theta\cos\theta_0 + \sin\theta\sin\theta_0\cos(\phi - \phi_0) \qquad (1)$$

The viewing and solar angles that are used by the AAI retrieval code are given w.r.t. sea level and correspond to the middle of the integration time of a measurement footprint.

1.3 Suggested reading material

The following paper describes the retrieval algorithm when applied to GOME [3] data, and analyses the quality of the data. A proper sensitivity study is also presented in this paper.

M. de Graaf, P. Stammes, O. Torres, and R. B. A. Koelemeijer, *Absorbing Aerosol Index: Sensitivity analysis, application to GOME and comparison with TOMS*, J. Geophys. Res. **110**, D01201, doi:10.1029/2004JD005178, 2005.

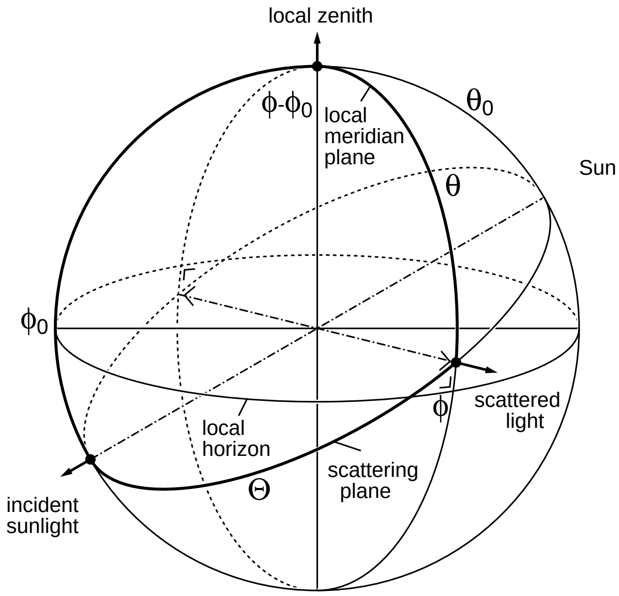

Figure 1: Definition of the solar and viewing angles as used in this PSD. The single scattering angle is denoted by Θ*, and is calculated using Eq. 1.*

In the following paper, the algorithm is applied to SCIAMACHY data:

L.G. Tilstra, M. de Graaf, I. Aben, and P. Stammes, *In-flight degradation correction of SCIAMACHY UV reflectances and Absorbing Aerosol Index*, J. Geophys. Res. **117**, D06209, doi:10.1029/2011JD016957, 2012.

1.4 Abbreviations and acronyms

AAI	Absorbing Aerosol Index
ATBD	Algorithm Theoretical Basis Document
BBA	Biomass Burning Aerosols
DAK	Doubling-Adding KNMI
DDA	Desert Dust Aerosols
DOAS	Differential Optical Absorption Spectroscopy
DU	Dobson Units, 2.69×10^{16} molecules cm^{-2}
ENVISAT	Environmental Satellite
ERS	European Remote Sensing Satellite
ESA	European Space Agency

ETOPO-4	Topographic & Bathymetric data set from the NGDC, 4 arc-min. resolution
FOV	Field-of-View
FRESCO	Fast Retrieval Scheme for Cloud Observables
GOME	Global Ozone Monitoring Experiment
IT	Integration Time
KNMI	Koninklijk Nederlands Meteorologisch Instituut (De Bilt, NL)
LUT	Look-Up Table
L2-AAI	Operational (level-2) Absorbing Aerosol Index product
MLS	Mid-Latitude Summer
NRT	Near-Real-Time
NOAA	National Oceanic and Atmospheric Administration
NGDC	NOAA's National Geophysical Data Center (Boulder, Colorado, USA)
NL-SCIA-DC	Netherlands SCIAMACHY Data Center
OMI	Ozone Monitoring Instrument
O3M SAF	Satellite Application Facility on Ozone Monitoring
PMD	Polarisation Measurement Device
PSD	Product Specification Document
RTM	Radiative Transfer Model
SBUV	Solar Backscatter Ultra-Violet radiometer
SC-AAI	SCIAMACHY Scientific Absorbing Aerosol Index product
SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric Chartography
SLS	Spectral Light Source
SRON	Netherlands Institute for Space Research (Utrecht, NL)
SZA	Solar Zenith Angle
TEMIS	Tropospheric Emission Monitoring Internet Service (http://www.temis.nl)
TOA	Top-of-Atmosphere
TOMS	Total Ozone Mapping Spectrometer
TOSOMI	Total Ozone algorithm for SCIAMACHY using the OMI algorithm
UTC	Universal Time Co-ordinate
UV	Ultra-Violet
VIS	Visible
VZA	Viewing Zenith Angle
WLS	White Light Source

2 Product description

The Absorbing Aerosol Index (AAI) is a dimensionless quantity which was introduced to provide information about the presence of UV-absorbing aerosols in the Earth's atmosphere [4, 5]. It is derived directly from another quantity, the residue r. The importance of this residue lies in its ability to effectively detect the presence of absorbing aerosols even in the presence of clouds. When a positive residue is found ($r > 0$), absorbing aerosols are certainly present in the observed scene. Negative or zero residues on the other hand ($r \leq 0$), suggest a definite absence of absorbing aerosols in the observed scene. For that reason, the AAI is traditionally defined as equal to the residue r where the residue is positive, while it is simply not defined where the residue has a negative value.

The SCIAMACHY AAI algorithm "SC-AAI" [6] is for the largest part a more or less direct implementation of the algorithm as described in reference [7], the major difference being that here the algorithm was applied to data from the GOME instrument [3] on board the ERS-2 satellite. An early version of the SC-AAI algorithm (version 1.0) was described in reference [8]. The most recent version of the SC-AAI algorithm, however, is an improvement in quite a number of important aspects:

– improved reflectance look-up tables
– better treatment of the phenomenon of surface elevation
– better and more accurate calculation of surface height
– viewing and solar angles are calculated w.r.t. the Earth's surface (instead of w.r.t. TOA)
– the Earth's sphericity is taken into account
– ozone variation is taken into account (requires ozone field as input)
– correction for calibration offset due to key data issues
– correction for instrument degradation (scan-angle dependent)
– correction for obstruction in the FOV for the westernmost scan-mirror positions
– generation of level-2 data meant for the public (since version 2.1)
– improved sunglint flagging
– flagging for solar eclipse events

The products that are available are:

– level-2 product
– daily gridded level-3 product
– monthly gridded level-3 product

These products are available in ASCII. Images of the daily and monthly global AAI distributions in GIF format are created and made available on the TEMIS website (http://www.temis.nl). Processing log files are available for each processed day and give additional information about the data.

The level-2 product is derived from cluster 9 of the SCIAMACHY spectrum, leading to a spatial resolution of 60×30 km^2, 120×30 km^2, or 240×30 km^2, depending on the latitude, or rather, on the applied integration time (IT). In most cases, however, the smaller footprint size of 60×30 km^2 is active. The SCIAMACHY swath is 960 km wide and there are on average 14 orbits per day. Global coverage is achieved in approximately six days. The AAI is calculated for most SCIAMACHY observations made looking at the sunlit part of the Earth's surface. However, data having an IT larger than 1.0 s and/or a solar zenith angle θ_0 larger than 85 degrees are filtered out.

Next to the residue, the level-2 data files contains other quantities calculated by the retrieval algorithm. These are the measured reflectances at 340 and 380 nm, the simulated reflectance at 340 nm, and the retrieved surface albedo at 380 nm. Note that the latter does not relate to a real surface albedo. It should therefore not be misused as such. The external input parameters surface height and the ozone column, necessary for the calculation of the AAI, are also available.

The SCIAMACHY AAI data set starts at 18 July 2002 and ends at 8 April 2012, covering almost an entire decade. The data set is regularly being reprocessed. For more precise information on the SC-AAI retrieval algorithm we have to refer to the SC-AAI ATBD [9].

3 Product format specification

3.1 Level-2 product

The level-2 product contains all measurements in a particular orbit that were not filtered out and that allowed calculation of the AAI (residue). The orbit files of each day are collected into one tar file. The orbit files themselves are in ASCII format and their filenames contain a date and time code to be able to directly link them to the original level-1b files. A tool to access these orbit files files using the programming language IDL can be found on the TEMIS website (http://www.temis.nl).

Contents of the header of the level-2 files:

- level-1b product file, orbit number, and data processor version
- measurement start and end date/time
- SC-AAI software version
- processing date and time
- wavelengths λ_0 and λ_1 (set to 340 and 380 nm, respectively)
- contact information and additional comment lines

Data content of the level-2 files:

The data content of the level-2 files is summarised in Table 1. Most descriptions will speak for themselves, or are defined in the SC-AAI ATBD [9]. The meaning of the "multi-functional quality flag" is explained below. Each data line in the data file corresponds to a single observation. The first data line is preceeded by a line containing the data set names as used in Table 1.

Multi-functional quality flag:

The level-2 SC-AAI data product provides a quality flag for each measurement. The flag is given as a three-digit number (for example: "023"). Each digit refers to a specific sub-flag. The first digit indicates whether the pixel was affected by a solar eclipse event. A digit "0" indicates that the pixel was not affected. A digit "1" indicates that the pixel was most likely not affected, but that other parts of the orbit were affected. A digit "2" indicates that the pixel was definitely affected, and not to be used. Note that these events happen rarely, on average once or twice per year.

The second digit indicates the origin of the ozone column that was used. A value of "0" indicates the normal situation in which SCIAMACHY TOSOMI total ozone columns were available. If the flag is raised to "1", then assimilated SCIAMACHY total ozone values were used as back-up. If the flag is set to “2”, then ozone information was not available for some reason and a fixed standard ozone column of 334 DU was used. The latter situation should not occur in practice.

The third digit corresponds to the outcome of the sunglint test. If the flag is set to “1”, then the scattering geometry was such that sunglint could not have occurred, in other words, $\Delta\Psi_{\mathrm{glint}} > 22°$. If the flag is set to “2”, then the scattering geometry would have enabled sunglint to occur, i.e., $\Delta\Psi_{\mathrm{glint}} \leq 22°$, but the scene was over land. If the flag is set to “3”, then the sunglint scattering condition was met, the scene was over sea, yet covered by a thick cloud, preventing sunglint to occur. If the flag is set to “9”, then the pixel is regarded as a likely candidate for sunglint. A flag set to “8” indicates that the sunglint check was not switched on, but this flag should not occur in practice.

1 **data set name**	2 **data type**	3 **units**	4 **description**
time	float	s	time elapsed since 01-01-2000 00:00:00 UTC
it	float	s	integration time (0.25 s, 0.5 s, 1.0 s)
pid	integer	–	pixel identifier (restarting at 1 for each state)
sid	integer	–	state identifier (2–7, 9–15, 23–25, 38, 42–45)
vza	float	degrees	viewing zenith angle at the Earth’s surface
sza	float	degrees	solar zenith angle at the Earth’s surface
razi	float	degrees	relative azimuth angle at the Earth’s surface
lon1	float	degrees	longitude of corner point 1
lon2	float	degrees	longitude of corner point 2
lon3	float	degrees	longitude of corner point 3
lon4	float	degrees	longitude of corner point 4
lat1	float	degrees	latitude of corner point 1
lat2	float	degrees	latitude of corner point 2
lat3	float	degrees	latitude of corner point 3
lat4	float	degrees	latitude of corner point 4
R1meas	float	–	measured reflectance at 340 nm
R1calc	float	–	calculated reflectance at 340 nm
R2meas	float	–	measured reflectance at 380 nm
height	float	m	surface height
ozone	float	DU	total vertical ozone column
albedo	float	–	albedo
residue	float	–	residue
flag	integer	–	multi-functional quality flag

Table 1: Product Specification Table of the SC-AAI Absorbing Aerosol Index level-2 product. The meaning and interpretation of the “multi-functional quality flag” is explained in the text.

3.2 Daily gridded level-3 product

In this level-3 product, all measurements of the AAI (residue) on a particular day are distributed on a latitude/longitude grid. This grid is made up of 288 × 180 cells (longitude × latitude) stored in a compact way in small ASCII files. These ASCII files are especially easy to handle for users that are familiar with the TOMS AAI data format. The residue can be obtained from the raw integer data by subtracting the number 450 and division by a factor of 10. Apart from the file which holds the residue grid, a second file is available which contains the number of measurements inside the grid cells.

3.3 Daily AAI pictures

For each day, a global picture of the AAI is available. See Figure 2 for an example.

3.4 Daily AAI log files

Processing log files for all processed days can be found on the TEMIS website.

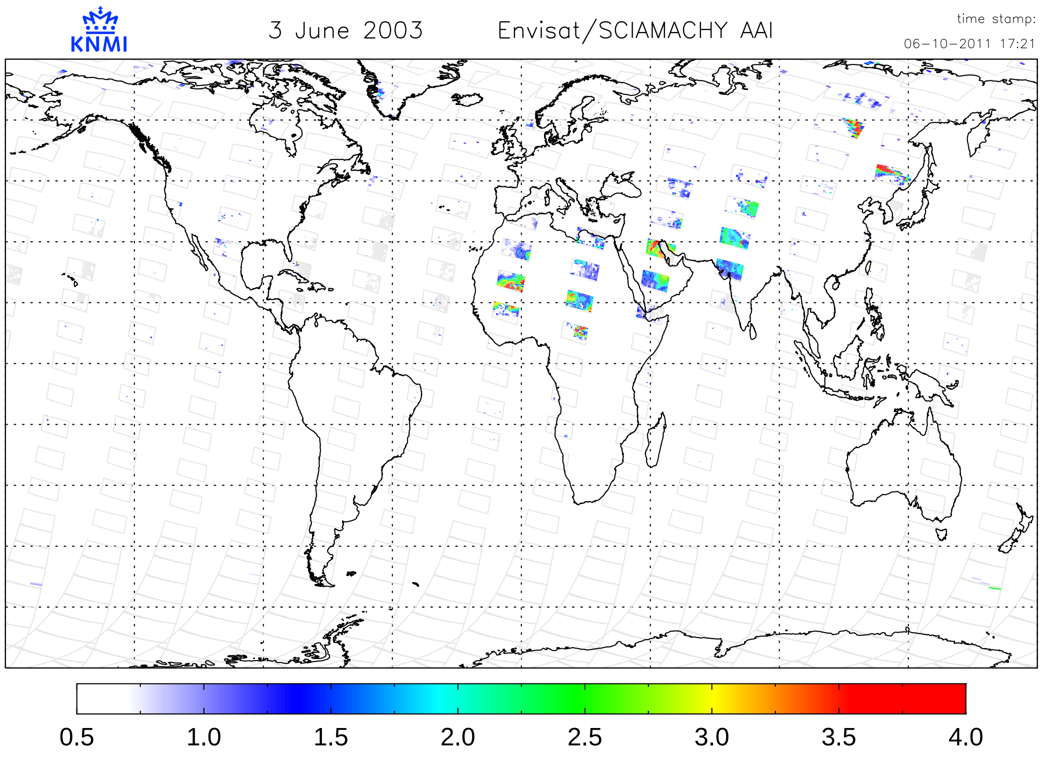

Figure 2: Daily picture of the AAI, for 3 June 2003. Negative residues are not shown, positive residues are related to the presence of UV-absorbing aerosols. Pixels affected by sunglint are grey.

3.5 Monthly gridded level-3 product

Monthly means of the AAI are stored in the gridded level-3 format explained in Section 3.2. The monthly means are means taken of the AAI, not of the residue. Consult the SC-AAI ATBD [9] for the difference between AAI and residue. The AAI values can be found from the raw integer data by dividing the latter by a factor of 10. Note that, because of the choice to average the AAI instead of the residue, the monthly data are strongly biassed towards occasional aerosol events (forest fires, volcanic eruptions) rather than that the data show a representative mean for the entire month.

3.6 Monthly AAI pictures

For each month, a global picture of the monthly mean AAI is available, based on the monthly gridded AAI data described in Section 3.5. See Figure 3 for an example.

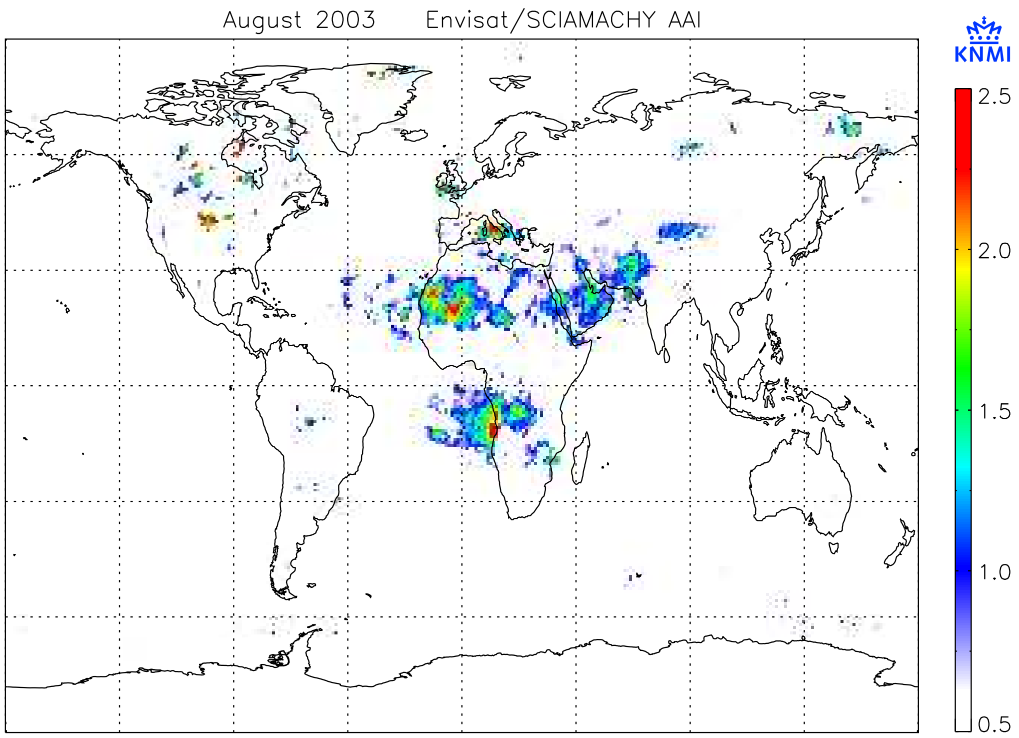

Figure 3: Global map of the monthly mean SCIAMACHY AAI for August 2003. The two aerosol plumes are related to dust events (desert dust, larger plume) and biomass burning (smaller plume).

4 Software release history

Current release is version 5.1. The following is a dump of the software development history log file. As a result, also less relevant information about improvements of the software code is included.

```
1.0 first official release, released 15-07-2004

- LUTs calculated with a radiative transfer code that includes polarisation.
- radiometric calibration correction applied to the reflectances.
- sunglint filter removes potential sunglint situations.
- limited data availability (only data for the year 2004 is available).
```

```
2.0 second major release, released 29-11-2006

- fixed a number of bugs that occasionally caused the code to crash.
- removed a large number of less important bugs.
- replaced "scia_aai.pro" by the new procedure "scia_aai_orbit.pro".
- combined NRT and OFFLINE functionality into one code for clarity.
- introduced some cosmetic changes to the daily pictures.
- better handling of situations in which multiple files for one orbit exist.
- determined calibration correction for software version SCIA/6.02.
- entire dataset made available to the public.
```

```
2.1 released 02-03-2007

- code now makes use of the NADC tool "scia_nl1" instead of "scial1c".
- better and more economic accessing of level-1c data via BEAT.
- rearranged the code to make it faster; cleaned up the code.
- arranged binary access to the GTOPO-based surface type database.
- better handling of errors in the level-1c data product.
- set sunglint angle cut-off to 18 degrees (instead of 12 degrees).
- replaced "scia_aai_sunglint.pro" by the new "get_surface_type.pro".
- generated ASCII level-2 data are now available on the TEMIS site.
- processing log files are now also available on the TEMIS site.
```

```
2.2 released 12-10-2007

- replaced "scia_aai_pressure.pro" by the completely new surface height
  calculation routine "get_surface_height.pro".
- created a new surface height database with a much higher resolution.
- arranged binary access to this surface height database.
- improved residue calculation (ported to IDL, no ASCII transfer).
- replaced "residuein.pro", "residueout.pro", and "residue.f90" by
  the completely new "calculate_residue.pro".
- improved LUTs: based on radiative transfer simulations with a better
  treatment of the phenomenon of surface height.
- changes required new format for level-2 files ("write_aai_level2.pro").
```

```
2.3 released 17-12-2007

- instructed the code to skip version SCIA/6.01 data.
- some cosmetic changes to the daily pictures and processing log files.
- added calibration correction component "scia_aai_calibration.pro".
- redetermined calibration correction for software version SCIA/6.0x.
- correction for instrument degradation (scan-angle independent).
```

```
3.0 third major release, released 09-03-2008

- used only level-1 data of:

  > reprocessed (R) orbits                     (SCIA/6.03)
  > near real time (NRT) orbits                (SCIA/6.03)
  > consolidated (P) orbits                    (SCIA/6.02)
  > consolidated (P) orbits                    (SCIA/5.04)

  (in that preferred order)

- minor changes in the software with respect to previous version.
- added a 'skip list' of files that should be skipped for whatever reason.
- some cosmetic changes to the daily pictures and processing log files.
```

```
3.1 released 28-04-2008

- proper treatment of monitoring states, to be specific:

  > no removal of backscan pixels for monitoring states
  > proper display of data and states of state_ID 38 in daily pictures
  > notification of monitoring orbits in processing log files

- scan-angle dependent correction for instrument degradation:

  > for each integration time (IT)
  > for each pixel inside the scan from east to west and back

  However, monitoring states are not treated correctly (yet).

- correction for the obstruction in the FOV for westernmost pixels that
  was present until the end of March 2003. Only for state_ID 1--7. The
  other state_IDs do not suffer from this obstruction, with the one and
  only exception being 'nadir static' states in the extreme west viewing
  direction (POS_ESM = +32, 01-SEP-2002).
```

```
3.2 released 15-05-2008

- as v3.1, but with proper degradation correction for monitoring states:

  > narrow swath          (state_ID 9--15)
  > nadir static          (state_ID 23--25,42--45)
  > nadir pointing left   (state_ID 38)

- temporarily removed monitoring data from 01-SEP-2002 from the level-3
  monthly data. See last comment in description of version 3.1.
- minor changes in the software with respect to previous version.
- some cosmetic changes to the daily pictures and processing log files.
```

```
4.0 fourth major release, released 20-08-2008

- added ozone dependence to the residue calculation:

  > ozone column is now varied instead of fixed to 334 DU
  > calculated new LUT database to include ozone dependence
  > provided access to the TOSOMI SCIAMACHY ozone column database
  > handling of occasional missing ozone columns and outliers
  > assimilated SCIAMACHY ozone columns are available as backup

- added new procedure "get_level2_ozone.pro" --> TOSOMI ozone.
- added new procedure "get_assimilated_ozone.pro" --> assimilated ozone.
- modified "calculate_residue.pro" to handle the changes; wrote an IDL
  function to perform the necessary quadrilinear interpolations.
- arranged binary access of "calculate_residue.pro" to LUT database.
- removed the sunglint filtering, instead introduced a quality flag.
- modified the procedure "scia_aai_orbit.pro".
- changes required new format for level-2 files ("write_aai_level2.pro").
```

```
4.1 released 22-01-2010

- LUTs improved: calculated using pseudo-spherical RTM (DAK 3.1.1), with
  O2-O2 absorption taken into account (background value).
- viewing and solar angles are calculated w.r.t. sea level (instead of
  w.r.t. a 100-km level as for the original level-1b data).
- added new procedure "calculate_angles_at_sea_level.pro".
- added correction for the obstruction in the FOV for 'nadir static'
  states in the extreme west viewing direction (POS_ESM = +32, only used
  for 01-SEP-2002); changed the procedure "scia_aai_calibration.pro".
- improved the 'backscan pixel screening' backup-algorithm to also work
  in case of incomplete states in combination with missing measurements.
- added new procedure "scia_aai_backscan.pro".
- set sunglint angle cut-off to 22 degrees (instead of 18 degrees).
- improved sunglint flagging by using FRESCO cloud information.
- added new procedure "get_fresco_data.pro".
- added flagging for solar eclipse events that cause high residues.
- some cosmetic changes to the daily pictures:
  > indication of solar eclipse events (per state, in grey)
  > indication of sunglint situations with residue > 0 (in grey)
- modified procedures "scia_aai_orbit.pro" and "scia_aai_day.pro".
```

```
5.0 fifth major release, released 11-10-2011

- used level-1 data of:

  Until and including 31-12-2009:

  > reprocessed + consolidated (R) orbits       (SCIA/6.03)
  > consolidated (P) orbits                     (SCIA/6.02)
  > near real time (NRT) orbits                 (SCIA/6.03, SCIA/6.02)
  > consolidated (P) orbits                     (SCIA/5.04)

  After and including 01-01-2010:

  > reprocessed + consolidated (U) orbits       (SCIA/7.03, SCIA/7.04)
  > near real time (NRT) orbits                 (SCIA/7.04, SCIA/7.03)

- greatly improved the correction for instrument degradation: correction
  is performed on the reflectances at 340 and 380 nm instead of on the
  residue. At the same time we correct for the rather large impact of
  instrument decontamination events on the UV reflectance.
- small improvement in "t=0" calibration correction coefficients.
- improved gathering of TOSOMI and FRESCO data.
- interpolation now fully performed by own routines "bl_interpolate.pro"
  and "ql_interpolate.pro", which both extrapolate when necessary. This
  is only relevant for ozone columns exceeding 650 DU and surface heights
  exceeding 8.0 km. These situations are quite rare.
- some cosmetic changes to the daily pictures and log files; reduced
  verbosity level for log files to suppress less relevant processing messages.
```

```
5.1     released 07-06-2012

- used only level-1 data of:

  > reprocessed + consolidated (W) orbits       (SCIA/7.04)
  > reprocessed + consolidated (R) orbits       (SCIA/6.03)
  > consolidated (R) orbits                     (SCIA/6.05)
  > consolidated (P) orbits                     (SCIA/6.02)
  > near real time (NRT) orbits                 (SCIA/7.04, SCIA/7.03)
  > near real time (NRT) orbits                 (SCIA/6.03, SCIA/6.02)
  > consolidated (P) orbits                     (SCIA/5.04)
```

5 Implementation details

The current SC-AAI software version is 5.1, which was released in April 2012. The majority of the level-1b files that were processed were generated by SCIAMACHY level 0-1 data processor version 7.04. The processing level of these files is "W". We do not use any data from processing level "U". To fill occasional gaps in the data set caused by missing orbits, we allowed the following processor versions to step in as replacement when possible: first 6.05 (R) and 6.03 (R), then 6.02 (P), then 7.04 (N), 7.03 (N), 6.03 (N) and 6.02 (N), where the letter 'N' refers to a near-real-time (NRT) orbits. Finally, consolidated data from version 5.04 (P) had to be used for a few days in July 2002.

The level-1b files were calibrated into level-1c files using the `scia_nl1` extraction and calibration tool, which is part of the NADC tools package [10]. We used version 1.2.0. This version can, among other things, perform a correction for instrument degradation using so-called m-factor correction factors [11]. However, as of version 5.0 we do not apply the m-factor correction any more. The version number of the m-factor database we used for previous versions was 6.01 [12]. More details on the specific calibration step of level-1b to level-1c data can be found in the SC-AAI ATBD [9].

The wavelength pair chosen for the SC-AAI is $\lambda = 340$ nm, $\lambda_0 = 380$ nm, and the windows used to average over are $2\omega = 1.0$ nm wide [9]. To correct for the well-known calibration error of the SCIAMACHY reflectance [13], we multiply the reflectances at 340 and 380 nm by correction factors c_{340} and c_{380}, respectively. For processor versions up to 5.04 we use $c_{340} = 1.183$ and $c_{380} = 1.129$. For processor version 6.02 and higher the correction factors are $c_{340} = 1.008$ and $c_{380} = 0.989$.

A second correction involves the correction for the obstruction in the FOV for westernmost pixels that was present until orbit 5656 of March 31, 2003. The obstruction correction file used up to this particular orbit is `SCIA_OBS_CORR_340_380_25102010.sav`. The correction file used to correct for the scan-angle dependent instrument degradation was `SCIA_DEG_CORR_340_380_05062012.sav`. As for the look-up tables, the LUT file used was `SCIA_AAI_LUT_340_380_O3_SPH_O2O2_06032009.sav`.

As for the necessary input parameters, the surface heights were calculated using an ETOPO-4 based elevation database [14] having an angular resolution of 4 arc-minutes. The ozone columns were taken from the TOSOMI total ozone database. The TOSOMI data version used was 0.43. If for some reason TOSOMI ozone columns were not available, then assimilated SCIAMACHY total ozone columns were used as backup. The cloud parameters, used in part of the sunglint detection algorithm, were taken from SCIAMACHY FRESCO data. The FRESCO version number is 5.2. Solar eclipse events were flagged according to the information listed in Table 2 of Appendix A.

6 List of known issues

For the current data version (5.1), there are no known issues.

7 Data quality assessment

The SC-AAI (v5.1) was successfully validated following three different strategies. First of all, a direct comparison with the AAI (or rather, residue) from GOME-1 showed that there is a very good agreement between the two products, both qualitatively and quantitatively. This study was performed for a number of latitude bands as well as for 15 known aerosol regions. Also, the periodicity of the time series of the residues obtained from these latitude bands and regions indicated that instrument degradation was successfully corrected for. The results were presented in reference [15].

Secondly, an intercomparison study was performed in which the SCIAMACHY AAI (version 5.0) was compared measurement-by-measurement to the collocated AAI (or rather, residue) measured by GOME-2 on board the Metop satellite. The validation results were limited in the sense that the GOME-2 AAI turned out to be the limiting factor. To be more specific: the results for the years 2007 and 2008 show a good correlation between the SCIAMACHY and GOME-2 data, but a rather strong time dependent bias (offset) was found in the GOME-2 AAI. This bias is the result of instrument degradation. No correction exists at the moment. Nevertheless, the bias-corrected accuracy was shown to be below 0.5 index points, which is satisfactorily. It is more likely, though, that the accuracy of the SCIAMACHY AAI is much higher, i.e., well below the 0.5 index points. The results and the approach followed in this validation study were described extensively in reference [16].

Thirdly, we studied the behaviour of the global mean residue, which can be considered to be more or less constant throughout the year. This we did for each individual scan-mirror position. The global mean residues found are indeed more or less constant, and equal for all of the individual scan-mirror positions. This indicates that we have applied a proper degradation correction. A more detailed description of the results can be found in reference [6].

The current version (version 5.1) is an improvement on previous versions in a number of aspects. First, the simulated reflectances, stored in look-up tables, were improved by recalculating them, this time including the Earth's sphericity and O_2-O_2 absorption. Secondly, the viewing and solar angles were converted to angles at sea level, which is more representative of the actual situation. Thirdly, the correction for instrument degradation has been perfected, and is now only calculated for (and using) level-1 data, so that it is no longer depending on the quality of the AAI product itself. Resulting from these changes, modest but important changes of 0.1–0.4 index points are to be expected. All in all, the AAI (residue) is expected to be accurate to well within 0.5 index point level.

A Overview of solar eclipse events

The following table provides an overview of the major solar eclipse events that have occurred since the launch of Envisat in March 2002. The first column lists the dates on which the solar eclipse event occurred, the second column lists the orbits which were affected. Usually one orbit is affected. The time interval in which the measurements were affected is found in the third and fourth column.

date	orbit	start time	end time
31-MAY-2003	06529	04:49:36 UTC	05:06:01 UTC
23-NOV-2003	09058	21:57:21 UTC	21:58:25 UTC
14-OCT-2004	13713	02:00:47 UTC	02:16:13 UTC
08-APR-2005	16242	18:45:50 UTC	19:08:01 UTC
03-OCT-2005	18784	08:33:18 UTC	08:40:35 UTC
03-OCT-2005	18785	10:12:58 UTC	10:22:20 UTC
29-MAR-2006	21318	09:15:00 UTC	09:24:22 UTC
22-SEP-2006	23853	11:40:43 UTC	11:52:09 UTC
19-MAR-2007	26396	03:00:21 UTC	03:07:38 UTC
11-SEP-2007	28921	13:07:23 UTC	13:21:06 UTC
01-AUG-2008	33572	10:23:53 UTC	10:40:19 UTC
26-JAN-2009	36117	06:07:35 UTC	06:23:10 UTC
22-JUL-2009	38648	01:24:19 UTC	01:37:49 UTC
15-JAN-2010	41184	05:34:18 UTC	05:45:44 UTC
11-JUL-2010	43725	18:00:10 UTC	18:05:22 UTC
04-JAN-2011	46257	08:35:18 UTC	08:51:35 UTC
25-NOV-2011	50924	05:40:24 UTC	05:59:33 UTC

Table 2: Solar eclipse events since the launch of Envisat. Date and orbit number of the affected orbits are given, as well as the time interval in which the measurements were noticeably affected.

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