SCIAMACHY Processor Baseline Summary Report

SCIAMACHY Level 0 to 2 processing

ENV-TN-QWG-SCIA-0127

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1 Introduction

1.1 Purpose and Scope of the document

SCIAMACHY is a joint project of Germany, The Netherlands and Belgium for atmospheric measurements. SCIAMACHY has been selected by the European Space Agency (ESA) for inclusion in the list of instruments for Earth observation research for the ENVISAT polar platform, which has been launched in 2002. The SCIAMACHY programme is currently in mission under the supervision of the SCIAMACHY science team (SSAG), headed by the Principal Investigators Professor J. P. Burrows (University of Bremen, Germany), Professor I.A.A. Aben (SRON, The Netherlands) and Dr. C. Muller (BIRA, Belgium).

The Quality Working Group has been installed in 2007 to intensify the development and implementation of the Algorithm Baseline for the operational data processing system of SCIAMACHY. Current members of the QWG are the University of Bremen (IFE) (Lead), BIRA, DLR, and SRON. The expertise of KNMI is brought in via an association with SRON.

In this document the status of the current processors of Level 0-1b and Level 1b-2 is described together with possible future improvements and open points.

1.2 Documents

1.2.1 Applicable Documents

Following documents are applicable for this technical note:

[A1] xxx

1.2.2 References

[R1] SCIAMACHY L0-1c Processor ATBD Algorithm Theoretical Baseline Document for Processor V.9 ENV-ATB-DLR-SCIA-0041 Issue 7, dd.mm.yyyy

[R2] SCIAMACHY Offline Processor Level1b-2 ATBD Algorithm Theoretical Baseline Document (SGP OL Version 7), ENV-ATB-QWG-SCIA-0085, Issue 3, dd.mm.yyyy

[R3] Verification L01

[R4] Verification L12

[R5] Validation L01

[R6] Validation L1b2

1.3 Abbreviations and Acronyms

BIRA	Belgisch Instituut voor Ruimte-Aëronmie
DLR	Deutsche Zentrum für Luft- und Raumfahrt e.V.
ENVISAT	Environmental Satellite
ESA	European Space Agency
IECF	Instrument Engineering and Calibration Facility
IUP-UB	Institut für Umweltphysik der Universität Bremen
SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric Chartography
SQWG	SCIAMACHY Quality Working Group
SRON	Netherlands Institute for Space Research
SSAG	SCIAMACHY Science Advisory Group

1.4 Document Overview

2 QWG Structure and Description

- Short introduction how it all works together
- Possible future set-ups in ESA (and national?) context

3 Current Implementation of Operational Processors

3.1 Level 0-1b Processor Version 9

Each section contains a *very short* explanation of the correction (details as reference to ATBD) and an estimate of the quality of the correction or correction data (from validation where available)

3.1.1 Detector Corrections

3.1.2 Stray Light

3.1.3 Polarisation

3.1.4 Spectral Calibration

3.1.5 Radiometric Calibration

3.1.6 Sun References

3.1.7 Degradation Correction

3.1.8 Auxiliary Data

- Moon
- Sun Mirror
- PMDs
- Polarisation fractions
- WLS
- SLS
- Other Monitoring (extra mirror etc)
- Geolocation

3.1.9 Data Format

3.1.10 Open Points

- Light Leak Channel 7
- NL UV/VIS ??

3.2 Level 1b-2 Processor Version 7

Each section contains a *very short* explanation of the correction (details as reference to ATBD) and an estimate of the quality of the correction or correction data (from validation where available)

3.2.1 Nadir Cloud & Aerosol

3.2.2 Nadir UV/VIS DOAS

3.2.3 Nadir UV/VIS Direct Retrievals

3.2.4 Nadir SWIR

3.2.5 Limb Clouds

3.2.6 Limb Profiles

3.2.7 Tropospheric Products

3.2.8 Data Format

4 Possible Improvements Level 0-1b Processor

Contains possible future improvements. Open points (where we have no or an insufficient correction yet should also be mentioned).

4.1 Detector Corrections UV/VIS

- Darks
- Memory Effect

4.1.1 XYZ

Motivation

Why do we need this, what is it useful for, where is it used

Method/Algorithm

How?

4.2 Detector Corrections SWIR

- Darks
- Non-linearity

4.2.1 Extension of Bad Pixel Determination from individual Pixels

Motivation

Method

Method used in channel 8 to channel 6 (7)

4.3 Stray Light

4.3.1 Straylight Channel 7

Motivation

Channel 7 on board SCIAMACHY was originally included to measure CO2, our (most) important man-made greenhouse gas.
However currently Channel 7 is not used for any operational product due to the large straylight caused (most likely) by a light leak. Correcting for this straylight will allow for scientific use of the channel and the (so far not possible) retrieval of CO2, providing a new CO2 timeline over 10 years for both the public and policy-makers.

Method

Detailed analysis of the in-flight earth measurement in combination with available viewing geometries will allow to determine the cause of the light leak. Once the exact cause is known, a correction can be derived, either by adapting in-flight measurements or interpolating calibration measurements.

4.4 Polarisation Correction

4.4.1 Nadir

4.4.2 Limb

4.4.3 Sun Glint Polarisation

Motivation

A polarisation correction is applied to all SCIAMACHY observations (as SCIAMACHY is polarisation sensitive) which is in the order of several percent and varies over the scan angles. Earlier studies have shown this polarisation correction to be problematic, hence verification of this polarisation correction is essential for the SCIAMACHY radiance and reflectance precision.
The absolute values of SCIAMACHY's polarisation have never been verified as no reliable in-flight polarisation source was present. Only un-polarised scenes (sun, backscatter) were present, which only allow verification of an off-set in polarisation, but not the absolute scaling. Scientific measurements are in contrast almost always polarised.

Method

No reliable in-flight polarisation source was present in the early years of SCIAMACHY, however new studies and other (satellite) observations have significantly improved modelling of the polarisation caused by sun glint. SCIAMACHY scanning viewing geometry results in sun glint geometry in a significant fraction of its observations. Combining these observations (both science and polarisation) with the latest sun glint models will allow for an in flight verification of SCIAMACHY measured polarisation and thus the polarisation correction.

4.5 Spectral Calibration

4.5.1 Use Reference Method from Channel 6+ in Other Channels

Motivation

Method

4.6 Radiometric Calibration

4.6.1 Absolute Radiometric Calibration

Motivation

Currently there is several percent difference between different on-ground absolute radiometric calibration measurements. This uncertainty is thus also present in the calibrated SCIAMACHY solar mean reference, for many scientists the golden standard.
In order to maintain this golden standard level, the absolute calibration must be improved and this difference understood.

Method

By modelling the on-ground measurements and hence understanding of all setup, polarisation, and instrument effects this problem can likely be resolved. By uncoupling the (improved) BSDF from the on-ground absolute diffuser measurement, the absolute radiometric calibration can be more accurately determined.

4.6.2 Lunar Observations

Motivation

The moon is stable and always present, with highly predictable variations due to lunar phase, liberation and polarisation. This makes the moon a very good satellite (inter)calibration source. As yet no reference lunar spectra exist with SCIAMACHY spectral resolution.

Absolute radiometric calibrated lunar calibrated. In addition these observations will be a validation of the radiometric calibration of SCIAMACHY.

Method

Until now no attempts have been made to study the SCIAMACHY lunar observations, due to the large uncertainties in absolute calibration. SQWG has shown that this can be partly explained by the erroneous limb calibration keydata previously employed.

Including the new degradation correction derived from contaminated mirror analysis will provide the desired calibrated lunar observations. Comparison with (lower resolution) lunar spectra and Apollo lunar soil spectra will provide independent verification of the employed SCIAMACHY calibrations.

4.7 Degradation Correction

4.8 Sun Reference

4.8.1 BSDF Calibration

Motivation

The current fully calibrated ESM diffuser spectrum employed by SCIAMACHY is affected by additional spectral features (speckles) in the Bidirectional Reflectance Distribution Function (BSDF) of the (ESM) diffuser; this affected solar spectrum is used in e.g. ozone and aerosol retrieval. While a relative correction (to an arbitrary initial time/geometry) has been implemented, the initial (for the arbitrary time/geometry) BSDF speckles are not removed and remain as undesired spectral features in the solar irradiance and thus in the earth reflectance.

Method

Originally no solution was thought possible for this problem, hence it was not included in the latest SCIAMACHY data version, however the mirror model employed for degradation correction provided new insight. The theoretical modelling of the diffuser as a (contaminated) aluminium mirror with multi-facets combined with the dedicated (and non-dedicated) on-ground measurements.
The BSDF of the ESM diffuser will be calibrated through a combination of the SCIAMACHY scan mirror model, first principle assumptions on the diffuser properties, a combination of a large selection of on-ground and in-flight SCIAMACHY measurements, and through vicarious calibration such as solar spectra, lunar soil lab spectra, deep convective cloud spectra, desert spectra, etc.
These steps will allow for a clear separation between the broad-band BSDF and the through speckles introduced spectral features, greatly improving both the absolute solar irradiance and reflectance measurements.

4.8.2 Radiometric calibration of ASM diffuser spectra

Motivation

The following solar spectra are currently used in SCIAMACHY retrievals (see also Figure 4.1):

- **D0:**
  Fully calibrated ESM diffuser spectrum, affected by additional spectral features (speckles); this is used in e.g. ozone and aerosol retrieval.
- **A0:**
  ASM diffuser spectrum, no radiometric calibration, but by design less artificial differential features; this is preferred for DOAS-type applications.

Some additional solar spectra are contained in the L1 products, but these are mainly for monitoring purposes and mostly unused in retrieval applications.

With a radiometric calibration of the ASM diffuser spectra solar spectrum it would be possible to generate a single solar reference spectrum which could be used for all applications. This would not only reduce possible confusion on data user side (which solar spectrum shall be used in which case?), a solar spectrum having both accurate radiometric calibration and differential structures would be a benefit on its own.

Method

During the SQWG3 project a method has been developed to achieve a fully calibrated A0 spectrum by scaling it with a spectrally broadband factor derived from the ratio A0/D0. It has been decided not to implement this method into operational data processing, mainly because it is not possible to assess the quality of this new A0 solar spectrum in a sufficient way.

A more appropriate way to derive a calibrated A0 spectrum would be to include the ASM diffuser in the mirror model. This could be done in a similar way as for the ESM diffuser (with the difference that there is only limited on-ground information on the ASM diffuser). Such an implementation was considered to be not possible within the limited time frame of the SQWG3 project.

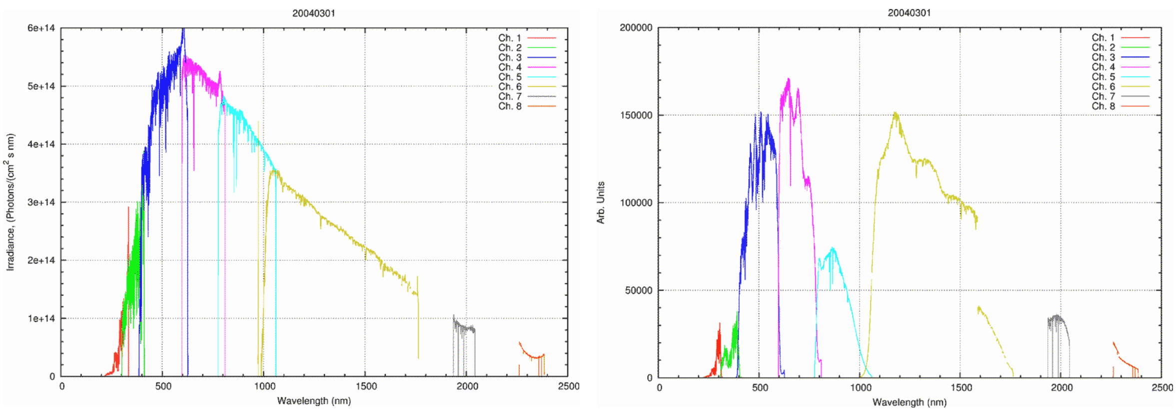

Figure 4.1: *Example of ESM diffuser solar spectrum (D0, left) and (uncalibrated) ASM diffuser solar spectrum (A0, right).*

4.9 Auxiliary Data

- Moon

Sun Mirror

- PMDs
- Polarisation fractions
- WLS
- SLS
- Other Monitoring (extra mirror etc)
- Geolocation

4.10 Other

4.11 Data Format

5 Possible Improvements Level 1b-2 Processor

5.1 Nadir Cloud & Aerosol

5.1.1 Product XYZ

Motivation

Method/Algorithm

5.2 Nadir UV/VIS DOAS

5.3 Nadir UV/VIS Direct Retrievals

5.4 Nadir SWIR

5.5 Limb Clouds

- Pattys algorithm

5.6 Limb Profiles

5.6.1 Upgrade...

...to scientific DLR algorithms

Motivation

Method/Algorithm

5.7 Tropospheric Products

5.7.1 Ozone

Motivation

Method/Algorithm

5.8 Data Format

6 Summary