SCIAMACHY VALIDATION

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ABSTRACT

The SCIAMACHY instrument on board ENVISAT will measure high-resolution spectra of the atmosphere. Concentrations of various atmospheric constituents will be derived from this. Validation is essential to ensure the quality of these derived parameters.
The objective of the validation is to establish the accuracy of SCIAMACHY data products. This will be achieved by the collection of suitable validation data from different ground-based, airborne and satellite instruments. With the use of appropriate tools and models, the SCIAMACHY and validation data sets will be analysed and compared.
The validation activities consists of two complementary parts: 'Core' validation, which provides a minimal but essential validation of SCIAMACHY and validation based on selected AO proposals.
Moreover, the validation is divided in three phases: the commissioning, main validation and the long-term validation phase, planned to continue throughout the lifetime of SCIAMACHY to ensure the quality of the data, independent of e.g. instrument degradation.

1. INTRODUCTION

The SCIAMACHY instrument will fly on board ENVISAT, planned for launch in 2000.
SCIAMACHY measures solar irradiance and Earth radiance spectra. The SCIAMACHY processor derives from these spectra concentrations of various atmospheric constituents (Ref. 1). Validation of SCIAMACHY is essential to ensure the quality of these derived parameters. The validation activities will be co-ordinated by the SCIAMACHY validation and interpretation group (SCIAVALIG), a sub-group of the SCIAMACHY Science Advisory Group (SSAG). The programme for the validation of SCIAMACHY data products is described in detail in the SCIAMACHY Validation Requirements Document (Ref. 2), prepared by the SCIAVALIG.

Validation of the SCIAMACHY measurements is a challenge, due to the broad range of data products that can be derived in nadir, limb and occultation measurements. In addition to the validation of the calibrated spectra it is necessary to assess the performance of the processing algorithms in converting radiances into atmospheric parameters, and to determine random and systematic errors associated with any resulting data product.

2. VALIDATION SET-UP

The validation activities will comprise both a core and AO validation programme.
The core validation is required to ensure a minimal but essential validation of SCIAMACHY data products. Table 1 shows which SCIAMACHY products will be validated in the core validation and which validation sources will be used to achieve this. The coordinating group takes initiative in the validation of the specific product and is point of contact for that validation exercise. The participating group is actively involved in the validation and collaborates with the coordinating and other participating groups.
The core validation activities will be complemented and enhanced by the wide ranging activities resulting from the selected Announcement of Opportunity (AO) validation proposals.

3. VALIDATION SOURCES

Validation will be done using ground-based, airborne and satellite measurements. At least one year of measurements are needed to cover the different seasons. In this validation programme, measurement campaigns for ground-based and airborne measurements, preferably coincidental with the overpass of the satellite, will be exploited. A database for measurements obtained during the validation phase of the instrument will be created.
Comparison with validated satellite measurements will be done using measurements at the same geolocation and time. As GOMOS and MIPAS (both on ENVISAT) will be validated at the same time, their measurements cannot be used as a primary source of validation during the first phase of validation. However, validation campaigns organised for GOMOS and MIPAS should be coordinated with the SCIAMACHY validation campaign and vice versa.

The following validation sources can be distinguished:

- In situ surface observations.
- Remote surface observations (lidar, Brewer, Dobson, SAOZ, FTIR, MW).
- Airborne observations (sondes, balloons, aircraft, rockets).
- (Validated) satellite data from other missions (e.g. GOME, TOMS, SAGE III, ATSR-2, MOPITT).
- Model calculations.

Of particular importance are data collected by networks such as NDSC (Network for Detection of Stratospheric Change) or

Table1: Specification of the core validation. Heid./IFE/MPI= Heidelberg/IFE Bremen/MPI-Mainz.

SCIAMACHY Product	Data sources used for core validation	Frequency of observation	Global coverage	Coordinating group	Participating group
Spectral Solar Irradiance	SOLSTICE (II)	n.a.	n.a.	BIRA	
	SOLSPEC	n.a.	n.a.	BIRA	IFE
	GOME	n.a.	n.a.	IFE	IFE
	VIRGO	n.a.	n.a.	BIRA	NASA
	Balloons	2-3 x p. season	mid- and polar lat.	Heid./IFE/MPI	LPMA
Spectral Earth Radiance/ Albedo	GOME	n.a.	n.a.	KNMI	
	SBUV-2	n.a.	n.a.	NASA-GSFC	IFE
	TOMS (albedo)	n.a.	n.a.	NASA-GSFC	
	AATSR	n.a.	n.a.	KNMI	
	Balloons	2-3 x p. season	mid- and polar lat.	Heid./IFE/MPI	BIRA, LPMA
Polarisation	GOME	n.a.	n.a.	KNMI	SRON
	POLDER	n.a.	n.a.	KNMI	SRON
O_3(C)	GOME	n.a.	n.a.	KNMI	IFE, DFD
	TOMS	n.a.	n.a.	KNMI	NASA
	Brewer/Dobson	daily	all latitude bands	KNMI/BIRA	
	SAOZ	daily	all latitude bands	BIRA	
	DOAS	daily	all latitude bands	Heid./IFE/MPI, BIRA	
	FTIR	daily	all latitude bands	BIRA	AWI
	Models	n.a.	n.a.	KNMI	
O_3(P)	SAGE III	n.a.	n.a.	NASA-Langley	IFE, AWI
	GOME	n.a.	n.a.	IFE-Bremen	RAL
	Ozonesondes	10 x p. season p. lat. band	4 latitude bands	KNMI	AWI
	Lidar	2-5 x p. week	4 latitude bands	BIRA	AWI, CNRS
	MW	1 x p. hour	5 NDSC stations	IFE	DWD, AWI
	Balloons	2-3 x p. season	mid- and polar lat.	Heid./IFE/MPI	CNRS, Jülich
	Models	n.a.	n.a.	KNMI	
NO_2 (C)	GOME	n.a.	n.a.	AWI	DWD
	FTIR	daily	all latitude bands	BIRA	AWI
	DOAS	daily	all latitude bands	Heid./IFE/MPI, BIRA	
	SAOZ	daily	all latitude bands	BIRA	
NO_2 (P)	SAGE III	n.a.	n.a.	NASA-Langley	IFE, AWI
	UV-vis DOAS	daily	all latitude bands	Heid./IFE/MPI	
	DOAS Balloon	20 x p. year	all latitude bands	BIRA	LPMA/CNRS
	Balloons	2-3 x p. season	mid- and polar lat.	Heid./IFE/MPI	LPMA/CNRS

Table1 (continued):

SCIAMACHY Product	Data sources used for core validation	Frequency of observation	Global coverage	Coordinating group	Participating group
BrO (C)	GOME	n.a.	n.a.	BIRA	
	UV-vis DOAS	daily	all latitude bands	Heid./IFE/MPI, BIRA	
BrO (P)	Balloons	2-3 x p. season	mid- and polar lat.	Heid./IFE/MPI	Jülich, LPMA
	UV-vis DOAS	daily	all latitude bands	Heid./IFE/MPI	
H_2O (C)	TOVS	n.a.	n.a.	KNMI	
	radiosondes	2 x p. day	mainly Northern mid-lat.	KNMI	
H_2O (P)	SAGE III	n.a.	n.a.	NASA-Langley	IFE, AWI
	MW		5 NDSC stations	IFE	BIRA
	ECMWF	n.a.	n.a.	KNMI	
	Balloons	2-3 x p. season	mid- and polar lat.	Heid./IFE/MPI	CNRS, Jülich
N_2O (C)	FTIR	1 x p. week	Jungfraujoch, Ny-Aalesund	BIRA	AWI
N_2O (P)	Grab-/Cryosampler	1-4 x p. year	mid- and polar lat.	Uni-Frankfurt	CNRS, Jülich
CO_2 (C)	FTIR	1 x p. week	Jungfraujoch	BIRA	
CO_2 (P)	Cryosampler	1-2 x p. year	mid- and polar lat.	Uni-Frankfurt	FZJ
CO (C)	FTIR	1 x p. week	Jungfraujoch	BIRA	IFE, AWI
	MOPITT	n.a.	n.a.	SRON	NCAR, KNMI
	IR spectrometer	1 x p. week	Toronto	KNMI	Uni. Toronto
CO (P)	Balloons	2-3 x p. season	mid- and polar lat.	Heid./IFE/MPI	LPMA/CNRS
CH_4 (C)	FTIR	1 x p. week	Jungfraujoch	BIRA	
	MOPITT	n.a.	n.a.	SRON	NCAR, KNMI
CH_4 (P)	Balloons	2-3 x p. season	mid- and polar lat.	Heiid./IFE/MPI	LPMA/CNRS
	Cryosampler	1-2 x p. year	mid- and polar lat.	Uni-Frankfurt	FZJ
Temperature	TOVS	n.a.	n.a.	KNMI	IFE
Pressure (P)	ECMWF	n.a.	n.a.	KNMI	IFE
	Radiosondes	2 x p. day	mainly Northern midlat.	KNMI	IFE
Cloud cover	MVIRI (Meteosat)	n.a.	n.a.	KNMI	
	AATSR	n.a.	n.a.	KNMI	
Cloud Top Height	MVIRI (Meteosat)	n.a.	n.a.	KNMI	
	AATSR	n.a.	n.a.	KNMI	
Aerosols	Lidar	1-3 x p. week	Ny-Aalesund	AWI	
	Backscatter sondes	10 x p. winter	Ny-Aalesund	AWI	
	Sun photometers	2 x p. week	global	KNMI	
OClO*(C)	DOAS	daily	high + middle lat.	BIRA, Heid./IFE/MPI	
SO_2*(C)	TOMS	n.a.	n.a.	NASA-GSFC	
HCHO*(C)	GOME	n.a.	n.a.	Heid./IFE/MPI	

* Special Products, only observed under special conditions or after averaging

TOR (Tropospheric Ozone Research network), where data continuity is secured and the data is reliable and well validated.

4. TOOLS AND MODELS FOR VALIDATION

4.1 Coincidence Predictor

In order to maximise the effectiveness of any validation exercise it is important to make validatory measurements as close in time and space to the SCIAMACHY measurements as possible. To achieve this the PIs in field campaigns need a software tool that they may use locally that permits measurement strategies to be optimised. This predictor software should require only the orbital characteristics of the satellite and should be able to distinguish the footprint of both nadir and limb sounding measurements. A possible tool for this purpose might be the ENVISAT CFIs (Customer Furnished Items), in particular the ESOV (Earth observation Swath and Orbit Visualisation) programme.

4.2 Data Assimilation

Data assimilation is an important tool for the validation of satellite measurements (Ref. 3-5). For validation of a satellite instrument, several types of measurements, e.g. ground-based measurements, in-situ measurements, are used. Ground-based and in-situ measurements taken at different times and geographical locations than the satellite measurements are less suited for direct comparison. Also, satellite measurements usually represent averages over a large area, whereas conventional measurements often represent local values, which can make the two not readily comparable. Data obtained from other satellite instruments can also be used for validation, but suffer of much of the same problems.

Advection and assimilation models, which retain the dynamical information on ozone, make it possible to use non co-located ground-based and satellite measurements for validation. Data assimilation offers the possibility to identify ground stations which deliver controversial data by comparison with observations of a satellite instrument. Furthermore, models extended with data assimilation also produce statistical information on the quality of instruments and observations.

5. VALIDATION PHASES

There are three distinct phases of validation of SCIAMACHY data products: the commissioning phase, the main validation phase and the long-term validation phase.

5.1 Commissioning phase

Following the outgassing and functional testing of the instrument a preliminary validation will be performed. It is envisaged that this preliminary validation will proceed into the main validation phase.

5.2 Main validation phase

In this period each Level 1 and 2 product needs to be rigorously validated. An intensive campaign collecting data from ground-based, airborne and satellite instruments forms the basis of these activities. Analysis of these data and the SCIAMACHY data products provides the error assessment for the first official data release of validated SCIAMACHY products.

5.3 Long-term validation phase

One of the most important scientific contributions of SCIAMACHY is the establishment of trends in the geophysical parameters (trace gas distributions, atmospheric constituents, pressure and temperature fields) to be measured. Since the performance of all instruments is likely to degrade in time, it is essential that a long-term validation of the SCIAMACHY data products is undertaken. This necessitates a regular, optimised, repetition of the essential elements of the main validation. The primary objective of the long-term validation phase is to establish a reliable data record from which trends can be derived.

6. TIME SCHEDULE

The overall time schedule for the validation phases is as follows (time is given in months after launch L):

Commissioning phase	
Outgassing	L - L+1
Functional Testing	L+1 - L+3
Commissioning phase data	L+3 - L+6
Campaigns using ground based and airborne sensors	L+3 - L+6
End of commissioning phase	L+6
Analysis of commissioning phase data	L+3 - L+9
Commissioning phase workshop	L+9
Preliminary data release after	L+9
Main validation phase	
Collection of data	L+6 - L+18
Analysis of data	L+6 - L+20
Main validation Workshop	L+20
Official data release after	L+20
Long-term validation phase	
Collection of data	from L+18
Analysis of data	from L+18
Validation workshops	L+32, L+38, L+44, etc.

Apart from the official workshops at the end of the commissioning phase and main validation phase, resulting in recommendations on data release, it is planned that there will be intermittent but regularly validation workshops, typically every six months.

Finally it is necessary that the long-term validation will be continued throughout the lifetime of SCIAMACHY.

REFERENCES

1. Burrows, J.P., K.V. Chance, H. van Dop, J. Fishman, J.E. Fredereicks, J.C. Geary, T. Johnson, G.W. Harris, I.S.A. Isaksen, G.K. Moortgat, C. Muller, D. Perner, U. Platt, J.P. Pommereau, E. Roeckner, W. Schneider, P. Simon, H. Sunquist and J. Vercheval, SCIAMACHY: A European proposal for atmospheric remote sensing from the ESA Polar Platform, Max-Planck-Institut für Chemie, Mainz Germany, 1988.
2. SCIAMACHY Validation Requirements Document, SVRD 1, 1998.

3. Levelt P.F., M.A.F. Allaart and H.M. Kelder, On the assimilation of total ozone satellite data, Ann. Geoph. 14, 1111 - 1118, 1996.
4. Levelt P.F., Ozone satellite data analysis, BCRS project 4.1/AO-02, NRSP-2 96-07, October 1996.
5. Studies of Ozone Distributions based on Assimilated satellite measurements (SODA), an EU project proposal, 1996-1999.