Development and Preparation of the Scientific Exploitation of the SCIAMACHY Instrument.

Christian Muller – Jean-Christopher Lambert - Paul Simon
Christian.muller@oma.be

The SCIAMACHY instrument is the only "announcement of opportunity" atmospheric instrument of the ENVISAT payload launched on the first of March 2002. It is a joint venture of Germany, the Netherlands and Belgium and in Belgium, it involves all the aspects of the mission including industrial development, operations, validation and interpretation as well as final scientific exploitation. The first in-flight tests (March 2002) confirm an excellent instrument status including the parts developed in Belgium.

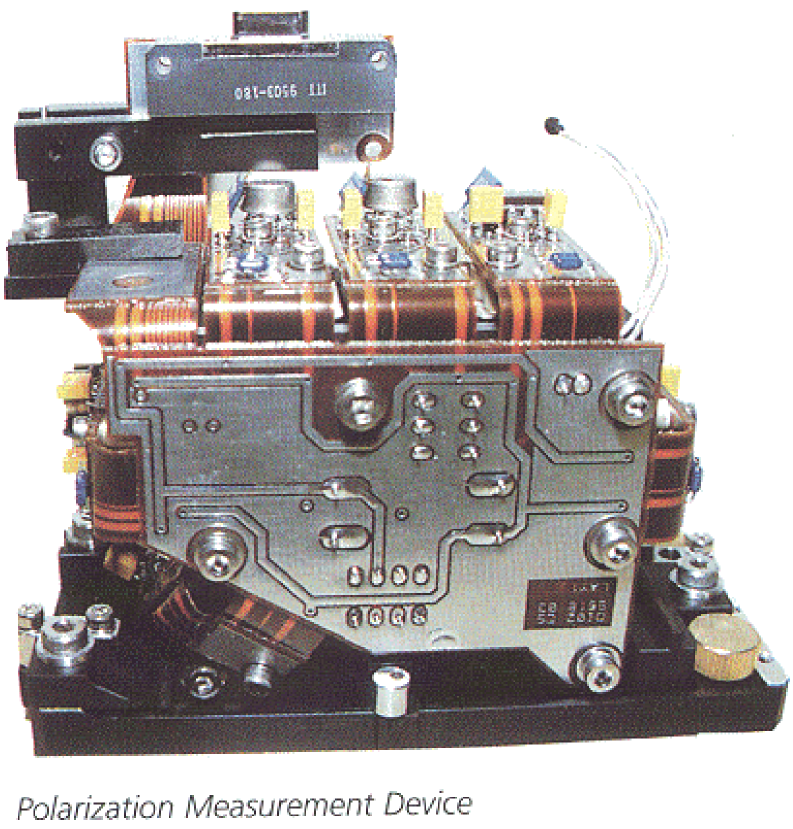

Figure 1: The SCIAMACHY polarization measuring device built in Belgium by the OIP Company in Oudenaerde.

SCIENTIFIC OBJECTIVES OF SCIAMACHY

The dramatic changes in the composition of the Earth's atmosphere discovered and observed during the past quarter of this century necessitate a detailed understanding of physical and chemical processes, which control the atmosphere on a global scale. SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY) was conceived in response to the lack of knowledge about the global behaviour of the stratospheric and tropospheric trace constituents, which play a dominant role in the processes, which occur in the Earth's atmosphere.

The primary objective of SCIAMACHY is to determine vertical and horizontal distributions of important atmospheric constituents and parameters (trace gases, aerosols, radiance, irradiance, clouds, temperature and pressure) from measurements of radiances consisting of scattered, absorbed and reflected light from the Earth atmosphere and Earth's surface. The radiances measurements will be done in different viewing geometries: nadir, limb and solar and lunar occultation. SCIAMACHY comprises a moderately high resolution (0.2-0.4 nm) spectrometer to observe transmitted, reflected and scattered light from the atmosphere in the UV, visible and near infrared wavelength regions over the range 240-1700 nm, and in 2 selected regions between 2.0 and 2.4 micron. The goal is to allow small optical absorptions (as small as 2E-4 in some regions of the spectrum) to be detected.
SCIAMACHY is designed to measure both tropospheric and stratospheric abundances of a number of atmospheric constituents, which take part in Ozone break-off or in the greenhouse effect. Targeted species are: in the troposphere - Ozone,O4, N2O, NO2, CH4, CO, CO2, H2O and aerosols and, in polluted conditions, SO2 in the stratosphere - Ozone, NO, NO2, NO3, CH4, CO2, H2O, OClO, BrO, aerosols, stratospheric clouds, and possibly, HCHO as recently demonstrated by GOME.
These measurements will contribute to our understanding of the following climate and environmental issues:

- Tropospheric pollution including industrial emission and biomass burning
- Troposphere/stratosphere exchange processes
- Stratospheric ozone chemistry
- Climate change - chemistry interactions
- Volcanic eruptions
- Solar variability.

The SCIAMACHY mission is a global mission with global coverage achieved each three days. Special facilities exist to measure regional events. The mission will contribute to the international climate and environmental programmes such as IGBP (International Geosphere Biosphere Programme), in particular the IGAC (International Global Atmospheric Chemistry) project and the WCRP (World Climate Research Programme).

Belgian involvement in the development of SCIAMACHY

The SCIAMACHY instrument flies aboard the ENVISAT-1 satellite as Announcement of Opportunity (AO) Instrument. The development and exploitation of the SCIAMACHY instrument is a joint undertaking of Germany, The Netherlands and Belgium.
The first SCIAMACHY proposal involved a European consortium of experts in atmospheric remote sensing including three Belgian scientists (C. Muller, P.C. Simon and J. Vercheval). It was based on several previous proposals and studies of, among others, a backscattered UV and visible ozone monitor from the geo-stationary orbit (Muller and Simon,1989).
The Instrument Providers have a joint interest in and responsibility for a properly functioning SCIAMACHY Instrument. The Polarisation Measuring Device (PMD) was developed and built in Belgium with the OIP Company (Oudenaarde) as prime Belgian contractor. The contribution of Belgium to the future phases of SCIAMACHY will be especially valuable in the areas of development, validation and exploitation of scientific data products, and in the area of industrial knowledge of the instrument itself and with respect to certain data products.
The Belgian co-Principal Investigator, C. Muller, acts as co-chairman of the SCIAMACHY Science Advisory Group (SSAG), as a member of the SCIAMACHY mission management bodies and will establish the necessary contacts with Belgian industry during flight operations.
The SCIAMACHY Validation and Interpretation Group (SCIAVALIG), a subgroup of the SSAG, is co-chaired by P.C. Simon, a Belgian co-Investigator of the instrument. An other Belgian scientist (J.C. Lambert) is validation coordinator for Belgium. Belgian scientists are involved at various levels in the development and exploitation of SCIAMACHY data products, among others through active collaboration

with the SCIAMACHY Algorithm Development and Data Usage subgroup (SADDU) and through official membership to SCIAVALIG and to the ESA's Atmospheric Chemistry Validation Team (ACVT).
Several Belgian scientific groups are interested in using the various data delivered by SCIAMACHY. The experience gained by IASB-BIRA and collaborating institutes in GOME and in scientific preparation for SCIAMACHY provides the basis of the contribution of the Belgian scientists to the international effort to produce SCIAMACHY data products. This requires adequate access to data. To make optimal use of the limited funding for the whole SCIAMACHY programme, the Belgian contribution should be focused on complementary activities based on the scientific expertise available within Belgium.

Overview of the Belgian contribution to retrieval algorithms

- **Polarisation data**
  - Studies based on synergy between GOME, POLDER and SCIAMACHY
- **UV products**
  - Validation of SCIAMACHY level-1 products
  - Development of a retrieval algorithm for solar Mg-II core-to-wing index
  - Development of a retrieval algorithm for UV index at the surface
  - Higher level products: maps of UV field and UV index at the surface
  - NRT validation of UV products (ground-based networks)
  - Database of space- and ground-based UV products
- **Spectroscopic studies and databases**
- **Retrieval algorithms**
  - Contribution to the GOME and SCIAMACHY level 1b-to-2 algorithm development
  - Development of a BrO processing algorithm
  - UV-visible DOAS studies
  - Climatologies of atmospheric species
  - Radiative transfer studies
  - Air Mass Factor studies
  - Limb aerosol retrieval studies
  - Intensive validation of level-2 products based on the synergistic use of ground-based networks, balloons and satellites, in collaboration with institutes world-wide; synergy with GOMOS, MIPAS, SAGE-III and TOMS validation.
- **Higher level products**
  - Development of higher-level products using assimilation tools, radiative transfer models and chemical-transport models (2D, 3D, and 4D-var, tropospheric and stratospheric), and their validation.

Polarisation data

The SCIAMACHY PMD (Polarisation Measuring Device) was developed in Belgium; it measures in six channels the polarisation status of the light entering each of the spectrometers. Its main purpose is to provide the basis for a polarisation correction on the main instrument channels, thus ensuring their radiometric accuracy. However, it can act as a science channel in itself for several important scientific objectives: cloud detection, aerosol characterisation and colour monitoring.

In synergy with the CNES POLDER instrument, SCIAMACHY yields part of the measurement parameters for aerosols: SCIAMACHY measures a complete spectrum but limited polarisation and no scattering angle dependency (bi-directional reflectance). From this data the aerosol optical thickness parameter can be retrieved. POLDER (operating in 1996-1997 aboard ADEOS-I) measures bi-directional reflectance and polarisation for a few wavelengths. POLDER will be flown again on ADEOS-II scheduled for launch in middle 2002 and will thus operate simultaneously with SCIAMACHY. Due to a possible circular polarisation component introduced in the signal by thermal stress in flight, this study might be necessary to provide the required radiometric accuracy. The combination of the data of both instruments will result in an improvement of the aerosol and cloud parameters.

UV data products

Due to the current downward trends in total column ozone at mid- and high-latitude, the expected increase in UV exposure as a result of this ozone loss may pose a significant health risk in the future and justify extensive UV monitoring programs. Furthermore, changes in human social behaviour add to this health concerns. In addition, detailed scientific knowledge of major atmospheric parameters influencing the global radiative balance at the ground level is also of crucial significance for atmospheric photochemistry. The amount of ultraviolet radiation reaching the ground is related to various atmospheric conditions: the incoming extraterrestrial flux, the ozone column, the cloudiness, the aerosol load, the local solar elevation (i.e. the time of day) and the reflectance of the underlying surface.

Satellite measurements are the only way to achieve a global view of the UV-B field. Based on previously acquired experience with the GOME instrument, IASB-BIRA proposes to assess the performance, accuracy and possible degradation of the SCIAMACHY instrument by comparing its solar flux measurements with simultaneously acquired data from other specialised spaceborne instruments. Most space instruments dealing with solar flux study use a limited wavelength window from the far UV to the visible part of the spectrum. While SCIAMACHY will have extended capabilities in the visible and infrared, the IASB-BIRA experience with GOME tells us that the UV channels are the most prone to degradation and accuracy problem due to the high energy of incident solar fluxes. In this respect, the SOLSTICE/UARS (in the future SOLSTICE/EOS) instrument, used for GOME instrument calibration, is perfectly suitable for assessing the performance of SCIAMACHY in the UV. In addition, another solar measurements instrument, SOLSPEC, will fly on board of the space station in 2006. This instrument has already flown several times during ATLAS missions providing valuable spectral measurements from the UV to the low infrared. IASB-BIRA being a co-investigator of this project, measurements from the visible part of the spectrum will adequately complement SOLSTICE's contribution.

Additionally, the solar UV validation activities also include the improvement of the Mg II index, a widely used solar activity proxies in the UV. Based on SOLSTICE algorithm, a GOME Mg II index has been developed and its extension to SCIAMACHY is of great importance for providing long term time series encompassing SOLSTICE, GOME and SCIAMACHY operation periods. Homogenisation of these various indices is essential for solar physics sciences.

First developments of a global UV-B field at the Earth's surface have already been conducted and have benefited from the ongoing experience of the GOME sensor. An accurate calculation of the UV-B flux reaching the ground level requires a good estimation of the cloud cover. In this respect, two approaches are investigated. The first one makes use of GOME/SCIAMACHY specific products: the cloud fraction estimation through the Initial Cloud Fitting Algorithm (ICFA) at regular pixels resolution and the off-line product developed at the DLR/DFD using PMD measurements at higher resolution. Preliminary studies have shown the potential value of both products. Both products are expected to be available and considerably improved with the SCIAMACHY sensor. Off-line PMD cloud fraction will be processed by DLR/DFD and will be made available for this activity.

These new solar products would not be conclusive without a robust validation of the scientific results. All preliminary scientific studies will be backed up by an EC-funded pilot project in which IASB-BIRA is involved: MApping UV by Europe (MAUVE). Beside the development of satellite UV maps at low and high resolution, MAUVE will also provide accurate ground-based UV-B measurements through SUVDAMA/UVRAPFF co-ordination for validation purpose.

Spectroscopic studies and databases

A main source of uncertainty in the SCIAMACHY retrieval algorithms arises from uncertainties in spectroscopic parameters and databases used in those algorithms. Spectroscopic studies are also fundamental for SCIAMACHY data retrieval algorithms other than those using the DOAS technique, as in the case of O_4, they can be unavoidable in order to understand the nature of the observed phenomena.

Belgian groups have been involved in absorption cross-section measurements since the beginnings of aeronomy notably in the determination of the O_2 absorption cross-sections in the Shumann-Runge bands, HNO_3 UV cross-sections and NO photo-dissociation coefficients. More recently, measurements have been also performed in the UV-visible region in co-operation between IASB-BIRA, the Laboratoire de Chimie Physique Moléculaire of the Université Libre de Bruxelles (ULB) and the Groupe de Spectrométrie Moléculaire et Atmosphérique of the Université de Reims (France). Several molecules have been investigated: SO_2, CS_2 and NO_2. In the case of NO_2, measurements have been performed at various temperatures. New measurements are currently in progress to validate these results and to analyse and quantify the effect of the pressure on the absorption cross sections of this molecule, which was detected during a previous study. Recently cross sections of the O_2 have been measured from the near IR to the UV. Experiments have been conducted using a 50 m multiple reflection cell, allowing the study of the spectra that were up to now attributed to the O_4 dimer. These studies have proved that the so-called O_4 spectrum is in fact due to collisional processes. Spectra of H_2O, HDO, and D_2O have been recorded from the near IR to the UV and their analysis is still in progress.

Retrieval algorithms

The retrieval of columns and profiles of atmospheric species from SCIAMACHY data is a complex task requiring experience in numerous scientific domains, such as applied optics and spectrometry, molecular and atomic spectroscopy, radiative transfer, astrophysics, numerical computing, and of course atmospheric chemistry, physics and dynamics. The know-how gained by Belgian institutes in these domains will be valuable in contributing to the development and maturation of SCIAMACHY level-1b-to-2 retrieval algorithms. In addition to the development of the UV and BrO products described in other sections, activities will concentrate on specific algorithm retrieval studies in the field of:

- Differential absorption spectroscopy (DOAS);
- Radiative transfer;
- Air Mass Factors (AMF);
- Climatology and databases of atmospheric species and parameters.

The GOME experience has demonstrated the obvious connection between retrieval studies and geophysical validation studies, as well as the significant benefit of carrying them out in parallel.

BrO data product

The importance of halogen oxides in the chemistry of the earth atmosphere has been raised following the observation of the Antarctic ozone hole in 1985 when the prominent role played by chlorine and bromine molecules of anthropogenic origin in the destruction of stratospheric ozone was discovered. It is now well established that catalytic cycles involving the ClO-dimer and the synergistic BrO-ClO mechanism are the main cause of the springtime O_3 loss occurring in the Antarctic and Arctic vortex. Being efficient at relatively large temperatures, bromine catalysed O_3 destruction mechanisms could play an important role in the long-term decline of ozone in middle latitudes, which has been reported over the last decade. In addition, BrO has been identified as an important ozone-destroying agent in the phenomenon of polar boundary layer ozone depletion.

A BrO product is currently developed at IASB-BIRA for the GOME instrument, in view of its application to SCIAMACHY. The retrieval of BrO total columns from radiance/irradiance measurements at nadir is a difficult task due to the low abundance of this minor atmospheric constituent. Typically absorption less than 0.1% has to be measured. Main difficulties for operational evaluation of BrO are well identified, and justify the development of a dedicated processor. These are:

- The small optical thickness to be detected;
- The presence of strong absorption bands of O3 interfering with those of BrO;
- The incomplete removal of Fraunhoffer structures when using a direct solar spectrum as a background;
- The lack of knowledge about the vertical distribution coupled to the photochemistry of the molecule, which makes it difficult to determine accurate air-mass factors for BrO;
- The lack of means to discriminate between BrO of tropospheric and stratospheric origins.

Current developments at IASB-BIRA address each of these difficulties. Such activities rely on:

- The experience gained at IASB-BIRA over the last few decades in the development of retrieval algorithms for spaceborne and ground-based optical experiments, in particular for the operational evaluation of DOAS measurements made since 1990 in the context of the NDSC and the Environmental Programme of the EU;

- The past and current involvement of IASB-BIRA in several projects focusing on the study of BrO and of the difficulties associated to its measurement by absorption methods;
- The close interaction/collaboration with IFE Bremen.
  As GOME can be considered as being a downsized version of SCIAMACHY, the experience gained from the first instrument is expected to be directly transmissible to the second one.

Higher level data products: 4D-Variational chemical data assimilation analyses

Global chemical composition analyses will be derived from chemical composition measurements using a 4D-Variational chemical assimilation system. The 4D-VAR assimilation will provide global chemical composition analyses consistent with dynamics and will provide global consistent information about unobserved chemical species.
This 4D-VAR-assimilation system will focus on global chemical composition and will thus be complementary to other ozone focussed fast delivery analysis systems. Projects are initiated to compare and assess the different analysis schemes.
The 4D-VAR chemical analyses will be provided to the user community on an operational basis. The time delay will mainly depend on the delivery of the chemical observational data. Although 4D-VAR assimilation analysis is known to be computationally expensive, the current 4D-VAR system developed and running at BIRA-IASB allows a timely delivery of the chemical analyses. The exact timing details will mainly depend on the definition and implementation of the data transfer.
The standard 4D-VAR assimilation system will be constrained by the official ESA, SCIAMACHY, MIPAS and GOMOS chemical products. Additional chemical products, available from AO projects, can easily be incorporated in the chemical observations constraining the assimilation analysis. These details are subject to further negotiations and implementation details.
The standard analysis deliverable can include global profiles of: ozone, nitrogen family species, chlorine family species, bromine family species, hydrogen family species, carbon species, long –lived tracers as N_2O, CH_4, CFC's. Spatio-temporal resolution of the distributed analyses will be defined in accordance with the user community requirements. The exact 4D-VAR assimilation system implementation details will be defined in agreement with ESA-ENVISAT and SCIAMACHY SAG and will also allow re-analysis of chemical updated algorithm observational data. The 4D-VAR assimilation system will be available for providing analysis during the validation phase.

Geophysical validation and scientific activities

Space-based measurements affected by a variety of instrumental and algorithm uncertainties. The performance of optical instruments degrades with time, especially in the space environment. Wavelength calibration and absolute signal level calibration are also subject to time-dependent drifts that may alter the accuracy of the retrieved atmospheric abundances. Satellite observations are of limited sensitivity in the lower stratosphere and the troposphere because of clouds, aerosols and other physical limitations. At small solar zenith angles (SZA), spectral signatures from weak absorbers or emitters may be near or under the detection threshold. At large SZA, the concentration of many relevant atmospheric constituents changes rapidly during twilight, making their retrieval more difficult and less accurate. Column and profile retrievals are sensitive to uncertainties in input parameters in the spectral analysis and in the radiative transfer model, such as laboratory absorption cross-sections, a priori assumptions in the composition and properties of the atmosphere or of the Earth's surface. Uncertainties due to features exhibiting a seasonal variation (e.g., vertical distributions of temperature and of radiatively active species, snow/ice cover) can result in periodic, systematic errors. Even under clear-sky conditions, uncertainties in the radiation field arise from large uncertainties in the spectral properties of the surface, which, in addition, may change significantly as a function of land use, vegetation, and season.
Therefore, before being used for specific scientific applications, and after each improvement of the retrieval algorithms, it is essential that the geophysical consistency of SCIAMACHY data products are investigated carefully by means of an intensive coordinated geophysical validation campaign. The primary purpose of the validation campaign is to verify that SCIAMACHY data do respond to spatial, temporal, and quality requirements specific of the application for which the experiment has been designed, such as atmospheric chemistry studies on the global scale and the detection of long-term trends. The accuracy and precision of the data must be assessed over the whole relevant spatial domain and vertical range during the entire mission.
The meaning of validation is broader than just verification of the fact that an instrument on the orbit operates well. It is more than simple data intercomparison. As illustrated by many papers in the scientific international literature, validation is a real scientific issue. Properly performed, it shows how remotely

retrieved distributions or abundances of atmospheric constituents relate to the true ones. In other words, validation results show how the satellite data can be used and interpreted by a broad scientific community. Moreover, through the validation effort, not only the satellite teams but also the validation teams are making progress as to the understanding and quality of their data, among others because of the inherent complementarity between the various techniques involved. In particular, iterative geophysical validation studies have proven to be an essential element of the maturation of retrieval algorithms. Finally, satellite observations are not continuous, since they depend strongly on space policies of the various nations. The link needed between sensors operating on different platforms must be studied. Validation is the only way to obtain global long-term contiguous data sets of high quality, exploiting latest technologies.

Validation strategy

The geophysical relevance of SCIAMACHY data products can be investigated by means of comparisons with high-quality correlative observations. Due to the broad range of geophysical products to be retrieved from nadir, limb and occultation observations, the efficient validation of SCIAMACHY data requires a well-structured approach based on the synergistic use of complementary data. The validation of SCIAMACHY should be embedded in the validation of the GOMOS and MIPAS instruments aboard the ENVISAT satellite.

Validation studies consist of successive steps:

1. Global verification and pre-analysis of satellite and correlative data;
2. Comparison of satellite with correlative data;
3. Interpretation of comparison results taking into account the error budget of each observation technique, the difference in air masses being compared, and the geophysical variability of the observed constituents;
4. Further investigation of the dependence of retrieval algorithms and retrieved quantities to measurement conditions and retrieval parameters, such as solar zenith angle, season, latitude, constituent profiles, temperature, and clouds;
5. Assessment of satellite data accuracy and precision;
6. Identification of problems and of possible solutions.

The Validation Requirements Document (SVDS-01) written by SCIAVALIG identifies the need for a ‘core’ validation and the necessities for its successful execution. The core validation activities encompass a minimal but essential validation of SCIAMACHY. These activities are under the responsibility of the Instrument Providers and will not be selected through an ESA peer review. In Belgium they are coordinated by IASB-BIRA. Although some of these activities may appear scientifically less challenging they still have to be performed to ensure a proper validation. ESA adopts the same approach for MIPAS and GOMOS.

The SCIAMACHY Validation Handbook (SVDS-02) describes both the core validation and the selected AO validation proposals.

Validation data base

A specific validation database will be needed to archive correlative data needed for validation. The SCIAMACHY data will be stored at DLR and will be available for the validation PIs. For GOME the validation database was set up at NILU in Norway and the users were satisfied with the services it provided. ESA intends to involve NILU again for the atmospheric instruments during the Commissioning phase of ENVISAT. ESA has offered the SCIAMACHY instrument providers to join in this effort. As a result SCIAMACHY can make use of the infrastructure and people covered by the ESA contract and does only have to cover the additional hardware (e.g., CD-ROM hardware) needed for SCIAMACHY. This would lead to a very cost effective approach and would enable SCIAMACHY to make use of the services of a provider that has proven its performance in guarding the quality of the collected data.

IASB-BIRA is co-ordinating group for the core validation of the SCIAMACHY Products listed in Table 1 with the specific data sources mentioned.

SCIAMACHY data product	**Validation data**		
	Data source	**Frequency/time**	**Estimated accuracy**
Spectral solar irradiance	SOLSTICE	Daily	170-320 nm: 5.7%; 280-420 nm: 7.9%
	SOLSPEC	n.a.	>From 5.1% at 240 nm to 2.5% at 850 nm
	VIRGO	Every 3 min.	Total integrated irradiance: precision<< 1%
O_3(C)	Brewer/Dobson	Daytime	2% (summer) to 5-7% (low sun and T)
	SAOZ	Daily, twilight	2.5% (summer) to 5% (polar winter)
	UV-vis DOAS	Daily, twilight	2.5% (summer) to 5% (polar winter)
	FTIR	Daytime*	2-3% precision
O_3(P)	Lidar	Nighttime**	Precision: 1% (15-35 km) to 15% (>40 km)
NO_2(C)	SAOZ	Daily, twilight	5-10%
	UV-vis DOAS	Daily, twilight	5-10%
	FTIR	Daytime*	2-3% precision
NO_2(P)	DOAS-Balloon	10/year, twilight	5% (from 8 to 35 km)
	UV-vis DOAS	Daily, twilight	10% on integrated stratospheric columns
BrO(C)	GOME	Daily	Error budget assessment in progress
	UV-vis DOAS	Daily, twilight	Error budget assessment in progress
OClO(C)	UV-vis DOAS	Winter, twilight	Error budget assessment in progress
N_2O(C)	FTIR	Daytime*	2-3% precision
CO_2(C)	FTIR	Daytime*	2-3% precision
CO(C)	FTIR	Daytime*	2-3% precision
CH_4(C)	FTIR	Daytime*	2-3% precision

* Frequency of FTIR observation: year-round, 2 weeks/month during commissioning phase, to 6x2 weeks/year during main and long-term validation phases
** Frequency of ozone lidar observations: year-round, several nights a week (weather permitting)

Table 1: Core validation of SCIAMACHY level-1 and level-2 data: products/sources co-ordinated by Belgium (C: integrated column; P: profile).

Spectral solar irradiance data, together with uncorrected Mg-II index, will be investigated to assess their accuracy and precision, to monitor instrumental degradation, and to spot additional instrument problems such as etalon and wavelength registration shifts. The investigation will rely on correlative solar measurements from space borne instruments such as SOLSTICE/UARS (operational since 1990), GOME/ERS-2 (since 1995), SOLSTICE-II/EOS (planned for 2002), SOLSPEC/space shuttle (5 flights from 1984 to 1994), SOLSPEC/ISS-α (planned for after 2002), and VIRGO-DIARAD/SOHO (operational since 1996). Scientists at BIRA-IASB and IRM-KMI are co-investigators of SOLSPEC and VIRGO-DIARAD, respectively.

The geophysical consistency of columns and profiles of constituents listed in Table 1 can be investigated by means of high quality correlative observations certified for the NDSC. This network of high-quality remote-sounding research stations started operating in 1991, under the auspices of the United Nations Environment Program (UNEP), the International Ozone Commission (IOC) of the International Association of Meteorology and Atmospheric Physics, and the World Meteorological Organization (WMO). Involved in the NDSC since its early commissioning, Belgium participates in various proposals relying on the integrated use of complementary NDSC data, and will co-ordinate several core validation activities based on following instruments associated with the NDSC: Dobson/Brewer spectrophotometers, UV-visible DOAS/SAOZ spectrometers, Fourier Transform Infrared (FTIR) spectrometers, ozone lidars.
The NDSC consists of about 17 sites distributed in five primary stations (Arctic, Alpine, Hawaii, New Zealand, Antarctic), and of two dozen complementary sites. NDSC-based core activities co-ordinated by Belgium are limited to primary stations of the NDSC while the investigation is extended to complementary stations and to other satellite sensors through AO proposals.
The core validation of SCIAMACHY BrO columns will also make use of the GOME BrO product developed at IASB-BIRA.

Belgian contribution to AO validation and scientific exploitation

Belgian teams are actively involved in both the validation and the scientific exploitation of SCIAMACHY data products through core validation activities and a number of selected AO projects. For the sake of efficiency, AO proposals have usually been designed to optimise connections between validation, retrieval and scientific aspects. For several proposals, the intended use of SCIAMACHY data is based on a synergistic approach combining various sources of information such as ground-based network data, balloons, other satellite data, modelling results, and assimilation tools. The achievement of AO projects will often benefit from international collaborations established with European and non-European research institutes.

Planned studies pursue the continuation of ongoing Belgian efforts and interests, and make an optimal use of existing experience. AO projects are relevant to themes of investigation including stratospheric ozone, solar radiation, UV fields and doses, tropospheric ozone and oxidising capacity, meteorological assimilation and forecast, aerosols, polarisation, mesosphere, aurora and airglow. Among others, proposals make use of ground-based instruments operated in Belgium and at NDSC stations by BIRA-IASB, IRM-KMI and ULg, as well as balloon-based sensors launched from Uccle and from other European sites and operated by IRM-KMI and BIRA-IASB. On many occasions, activities will rely on the heritage of the ATMOS, GOME, TOMS, SAGE-II and UARS validation and scientific exploitation, in which Belgium has played an important role.

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The SCIAMACHY validation requirement document and the SCIAMACHY validation handbook contain major contributions by scientists of IASB-BIRA, they can be obtained at the SCIAMACHY validation site: http://www.knmi.nl/sciamachy-validation/ .