Global Atmospheric Monitoring with SCIAMACHY

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Received 24 April 1998 – Accepted 5 November 1998

Abstract. SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY) is a space based spectrometer designed to measure sunlight transmitted, reflected and scattered by the Earth atmosphere or surface. It is a contribution to the Envisat-1 satellite to be launched in late 1999.

SCIAMACHY measurements will provide amounts and distribution of O_3, BrO, OClO, ClO, SO_2, H_2CO, NO_2, CO, CO_2, CH_4, H_2O, N_2O, pressure, temperature, aerosol, radiation, cloud cover and cloud top height from atmospheric measurements in nadir, limb and occultation geometry.

By the combination of the near simultaneous limb and nadir observations SCIAMACHY is one of a limited number of instruments which is able to detect tropospheric column amounts of O_3, NO_2, CO, CH_4, H_2O, N_2O, SO_2, H_2CO, and BrO down to the planetary boundary layer under cloud free conditions.

1 Introduction

1.1 What is SCIAMACHY?

The SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY) instrument is a space-based spectrometer designed to measure both the extraterrestrial solar irradiance and the upwelling radiation, i.e. sunlight which is transmitted, reflected and scattered by the Earth's atmosphere or surface. These measurements yield information about the amounts and distribution of atmospheric trace gases, clouds, aerosol, and the spectral reflectance (or albedo) of the Earth's surface.

The SCIAMACHY instrument was proposed in summer 1988 by the SCIAMACHY Science Team (Burrows et al., 1988). After peer review, SCIAMACHY was selected by ESA for flight on the Polar Platform, now known as Envisat-1, which is planned to be launched in late 1999. As a so-called 'Announcement of Opportunity' (AO) instrument, SCIAMACHY is a national contribution to the Envisat-1 mission funded by the German (DLR Bonn, formerly DARA GmbH) and Dutch (NIVR) space agencies, including a Belgian (IASB) contribution. SCIAMACHY complements well the other Envisat-1 atmospheric chemistry payload, namely the GOMOS, MIPAS, and MERIS instruments. A descoped version of SCIAMACHY, the Global Ozone Monitoring Experiment (GOME), is currently operating successfully from the ERS-2 satellite which was launched in April 1995 (see e.g. Burrows et al., 1997).

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This paper provides an overview on the capabilities of SCIAMACHY with a special emphasis on the troposphere. A more detailed description of the instrument and the mission can be found in Burrows et al. (1995) and Bovensmann et al. (1999).

1.2 Advantages of SCIAMACHY to GOME

There are two main advantages of SCIAMACHY with respect to GOME: its enhanced spectral range and additional atmospheric observation geometries. Whereas GOME concentrates on measurements in the UV and visible wavelength range (240 nm – 785 nm), SCIAMACHY also measures the solar part of the infrared spectral region. SCIAMACHY measures light continuously from 240 nm up to 1750 nm and in two spectral windows in the NIR (1940 nm – 2040 nm and 2265 nm – 2380 nm). This enables SCIAMACHY to detect important atmospheric trace gases with absorption features in the IR, most notably CO, CO_2, CH_4, and N_2O. Pressure, temperature, water vapour and aerosol information can also be obtained from this spectral region. As an overview, Figure 1 displays the atmospheric constituents which show significant absorption features in the wavelength range covered by GOME and SCIAMACHY.

A second significant advantage of SCIAMACHY is that in addition to the nadir viewing geometry SCIAMACHY will observe the atmosphere in limb and solar and lunar occultation geometry. The different viewing geometries are il-

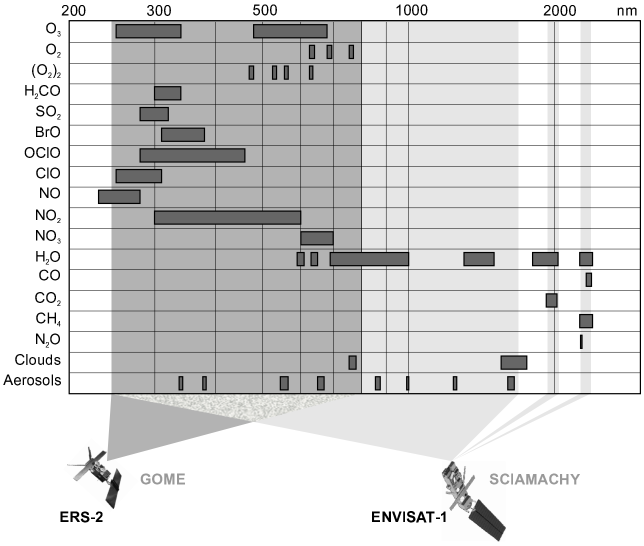

Fig. 1. Atmospheric constituents with absorption features in the spectral range covered by GOME and SCIAMACHY.

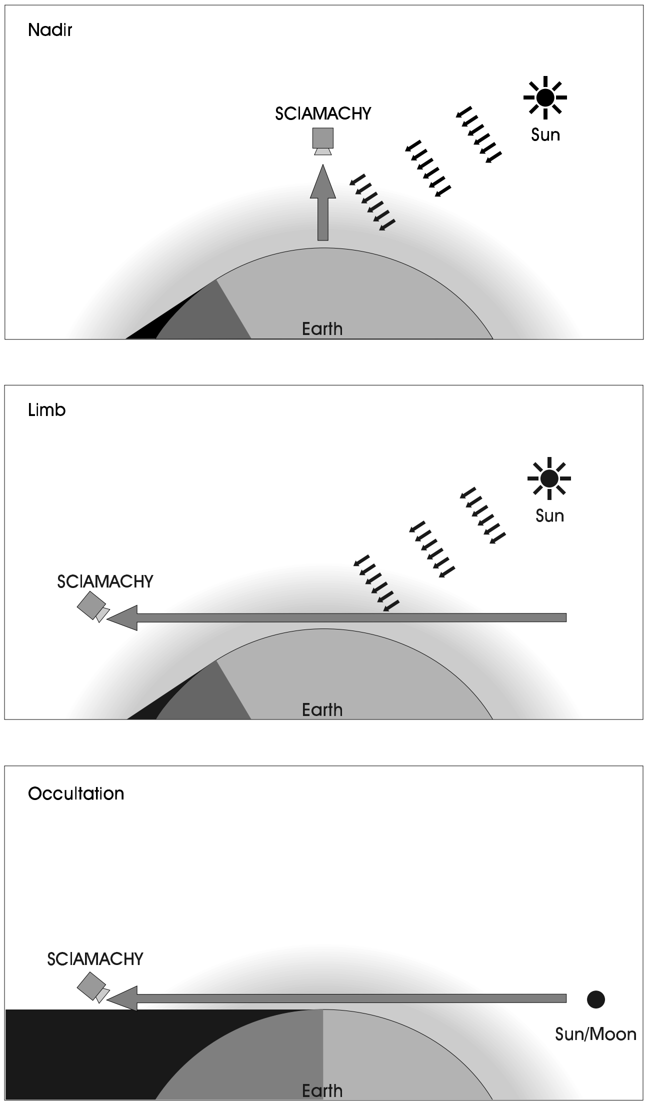

Fig. 2. Nadir mode (top): The atmospheric volume directly under the instrument (i.e. the spacecraft) is observed. Each scan covers an area on the ground of up to 960 km across track with a maximum resolution of 26 km $\times$ 15 km.
Limb mode (middle): The instrument looks at the edge of the atmosphere. Scans at different tangent altitudes over a range of up to 960 km in horizontal direction are performed with a geometrical vertical resolution of approximately 3 km.
Occultation mode (bottom): Measurements are performed using the same geometry as in limb mode, but with the sun or the moon in the instrument's field of view.

lustrated in Figure 2. Limb and occultation measurements will provide height-resolved information about atmospheric constituents on a regular basis. The combination of nadir and limb measurements will be used to derive tropospheric concentrations of several atmospheric trace gases on a global scale. This approach is described in more detail below.

2 Mission Objectives

Ozone measurements performed throughout the last years have shown that the loss of stratospheric ozone is not only confined to the antarctic region where the effect is most commonly referred as the ‘ozone hole’. A significant decrease of stratospheric ozone has also been observed over mid-latitudes (WMO, 1995) and the arctic region (Müller et al., 1997; Newman et al., 1997). The loss of stratospheric ozone is accompanied by a global increase of tropospheric ozone and of other tropospheric greenhouse gases such as CO_2, CH_4, and N_2O (IPCC, 1996). The recognition of these dramatic changes in the composition and behaviour of the atmosphere have emphasised the need for global measurements of atmospheric constituents in the stratosphere and the troposphere.

Although in-situ measurements can provide highly resolved information about the atmosphere, the only possibility to achieve atmospheric data on a global scale is given by satellite-based remote sensing techniques. In this context, great progress has been made over the last years in measuring global distributions of stratospheric trace gases. However, obtaining tropospheric information from satellite measurements still remains difficult because of the interferences by the Earth's surface and due to the presence of clouds. Therefore in the past very few satellite sensors were able to measure tropospheric constituents on a global scale. One of these sensors is the MAPS (Measurement of Air Pollution from Satellites) experiment which has measured global CO distribution during some flights of the Space Shuttle during the last years. A further MAPS mission from the Mir station is planned for mid 1998. Measurements of tropospheric concentrations of methane, N_2O, and CO were also foreseen from the IMG (Interferometric Monitor of Greenhouse Gases) instrument which was flown on the japanese ADEOS satellite. Unfortunately, ADEOS is no longer operating, thus there is currently no operational satellite instrument which can provide global measurements of tropo-

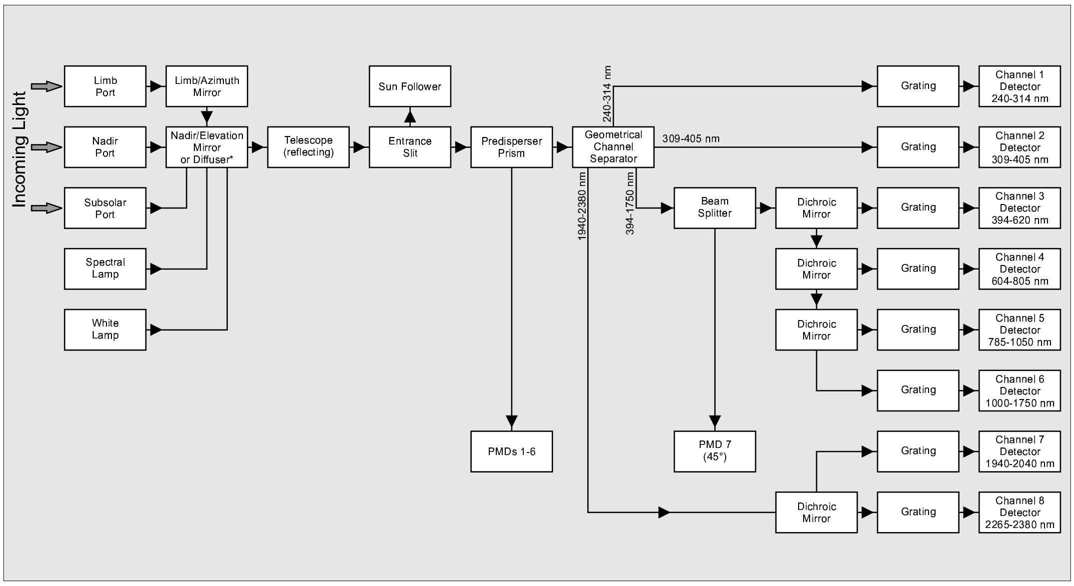

Fig. 3. Schematic view of SCIAMACHY light path.

spheric constituents (although there are some efforts to derive tropospheric ozone information out of existing data, see e.g. Munro et al. (1998)).

This situation will most likely become better in the near future when within the NASA/EOS project the MOPITT (Measurements Of Pollution In The Troposphere) instrument (on AM-1; launch foreseen mid 1998) and the TES (Tropospheric Emission Spectrometer; launch on EOS-CHEM in late 2002) will measure several tropospheric gases. A main objective of SCIAMACHY is to derive tropospheric information on a global and regular basis.

The overall aim of the SCIAMACHY mission is to improve our global knowledge and understanding of the Earth's atmosphere, i.e. the mesosphere, the stratosphere, and the troposphere, and to investigate potential changes which may result from anthropogenic activity or natural phenomena.

The amount and distribution of stratospheric ozone will be measured with a focus on the behaviour of the 'ozone hole' and on mid-latitude ozone. The coupling between stratosphere and troposphere will be investigated by measurements of the downward transport of stratospheric ozone and the upward transport of precursor molecules such as H_2O and N_2O. These originate in the planetary boundary layer and provide the feedstock for ozone-destroying HO_x and NO_x radicals.

As SCIAMACHY is one of a small number of instruments which will be able to derive tropospheric columns (see below), one of the major objectives is the investigation of tropospheric pollution from industrial activity and biomass burning.

Special events like volcanic eruptions, solar proton events, and related regional and global phenomena will also be a main focus of the SCIAMACHY project.

3 Instrument Characteristics

SCIAMACHY is a passive hyperspectral UV-VIS-NIR sensor. It comprises a UV-Vis-NIR imaging double spectrometer which is operated at a temperature of 253 K with a stability of 0.25 K. Each of its eight detectors consists of an 1024 pixel diode array. The detectors are cooled and stabilised to 0.02 K at temperatures between 150 K and 235 K. The main features of SCIAMACHY are a high straylight suppression ($< 10^4$), a moderately high spectral resolution of 0.2 nm to 1.5 nm (depending on the spectral region) and a high radiometric accuracy (absolute $<$ 2–4%, relative $<$ 1%) in combination with a spectral stability between 0.015 nm and 0.005 nm. The large dynamic range of SCIAMACHY covers 7 to 8 orders of magnitude.

The spatial resolution in nadir mode is typically 30 km $\times$ 60 km. The limiting factor in this case is for most of the orbit (i.e. latitudes between about 60°N and 60°S) not given by the sensitivity of the instrument to incoming radiation but by the maximum allowed data rate which requires an on-board coadding of data.

In limb and occultation mode, a typical vertical resolution of about 3 km will be achieved.

Figure 3 shows a schematic view of the SCIAMACHY light path. Incoming light enters the instrument via one of three ports:

(i) For nadir measurements the light falls via the nadir/elevation mirror on the entrance slit.

(ii) For limb and occultation measurements the limb port and an additional mirror (the limb or azimuth mirror) are used.

(iii) The subsolar port provides the possibility to observe directly the sun at a specific position in the orbit. This measurement and also spectra obtained from the internal lamps (a spectral and a white light source) are used for calibration and monitoring purposes.

A diffuser plate is mounted on the backside of the nadir mirror. The diffuser is used for solar irradiance measurements which are performed via the limb port after a solar occultation measurement when the sun is well above the atmosphere.

The telescope mirror focuses the light on the entrance slit. Part of the light which falls on the entrance slit is reflected to the sun follower.

At the predisperser prism a fraction of the light with a well-defined polarisation is distributed to the Polarisation Measurement Devices (PMDs) 1 to 6. The PMDs are photometers with a low spectral but high temporal/spatial resolution. Their main purpose is to provide information to correct the measured radiances for the polarisation properties of the instrument, but they are also useful for cloud detection. The light leaving the predisperser prism is spectrally resolved. Mirrors are then used to separate the two UV channels 1 and 2 and the IR channels 7 and 8 from the beam which then comprises light between 394 nm and 1075 nm. A small part of this light is directed by a beam splitter to PMD 7, which is sensitive to 45° polarised light. Dichroic mirrors perform an additional spectral separation of the main beam into the single channels 3 to 8. Each channel contains a grating which further disperses the light and directs the final spectrum to the detectors.

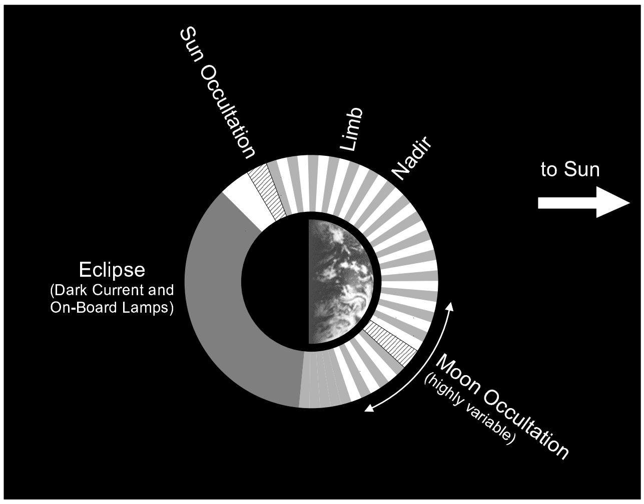

Fig. 4. Typical sequence of scientific measurements during one orbit. The orbit starts with limb measurements prior to sunrise; during sunrise solar occultation measurements are performed. Most of the sunlit part of the orbit consists of alternating limb/nadir measurements. When the moon is visible for SCIAMACHY (which is the case for about one week per month) moon occultation measurements are performed every second orbit on the southern hemisphere; the actual orbital position of these moon occultation measurements varies strongly over the year. The eclipse phase is dedicated to calibration measurements (mainly dark current measurements and measurements with the internal lamps). For the displayed measurement pattern global coverage is achieved within 6 days.

4 Sequence of Measurements in Orbit

Envisat-1 will fly in a polar, sun-synchronous orbit with a period of about 100 min, similar to the ERS-2 orbit but with an equator crossing time of 10 00 LT. Figure 7 shows which measurements are performed during a typical orbit. The latter comprises mainly alternating limb and nadir measurements. Every orbit during sunrise, solar occultation measurements including measurements of the solar irradiance are performed. Over the year, solar occultation measurements cover tangent latitudes between 90°N and 65°N. When the moon is visible (which is the case for about one week per month), lunar occultation measurements will be performed every second orbit. The position in the orbit where the moon is visible varies strongly over the year. Thus, moon occultation will cover a latitude range up to about 30° on the southern hemisphere. During eclipse, calibration measurements will be performed; this includes dark current measurements and measurements with the on-board lamps. For the nominal measurement pattern comprising alternating limb/nadir measurements global coverage is achieved within 6 days.

5 Retrieval Methods

The following subsections describe briefly the retrieval methods which will be used to derive atmospheric information from measured spectra.

5.1 Nadir Total Columns

The determination of vertical total columns from nadir measurements is based on the well-known DOAS (Differential Optical Absorption Spectroscopy) approach, which has been originally developed for on-ground observations (Brewer et al., 1973; Perner and Platt, 1979; Solomon et al., 1987) but has proven to be applicable also for space-based measurements (Burrows et al., 1997).

The DOAS technique seperates the measured signal (which is normalised to the unattenuated solar irradiance) into two parts: The first component which varies slowly with wavelength (this includes Rayleigh and Mie scattering and broadband absorption features) and the differential absorption component which shows significant spectral structures. The slowly-varying component is approximated by a low-order polynomial which is subtracted from the data. This is illustrated in Figure 5. The resultant differential signal is converted into a slant column amount, i.e. the amount of absorber(s) integrated along the light path through the atmosphere. This is determined by a least-squares-fit to a linear combination of differential reference absorption cross sections. Subsequently, a radiative transfer model (RTM) is used to convert the slant columns into vertical columns. This last step requires a-priori climatological information for shorter wavelengths where multiple scattering is significant.

The great advantages of the DOAS method are its ready implementation and the high computational speed, especially when using look-up tables instead of RTM calculations. This

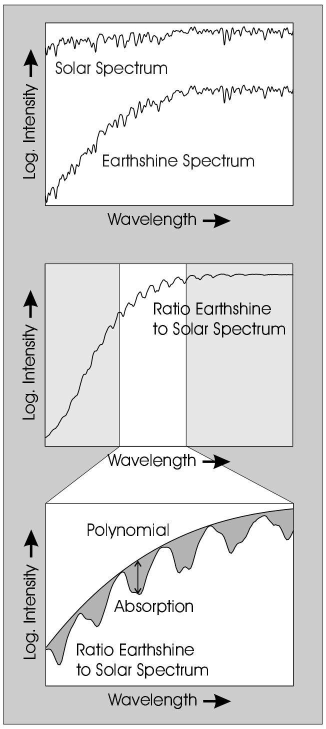

Fig. 5. Principle idea of DOAS: The earthshine radiance is normalised to the extraterrestrial solar irradiance. From the resulting signal, components which vary slowly with wavelength are approximated by a polynomial; absorption cross sections are fitted to the remaining differential structure.

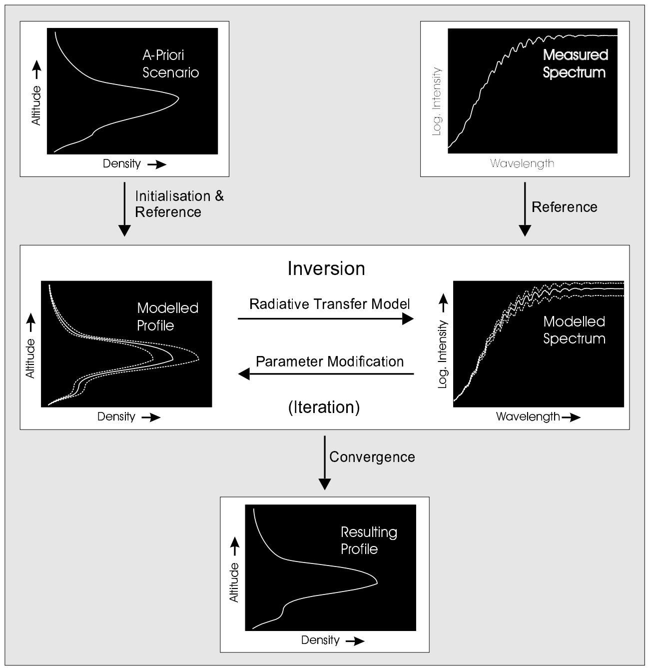

Fig. 6. Derivation of profile information from nadir measurements with FURM.

makes DOAS extremely useful for operational processing. In fact, this method has been shown to work successfully for GOME O_3 and NO_2 on an operational basis, but also in case studies for BrO, OClO, SO_2, and H_2CO (Burrows et al., 1997).

5.2 Profiles from Nadir Measurements

In addition to the total column it is also possible to derive vertical profiles of trace gas densities from nadir measurements using the so-called FUll Retrieval Method (FURM).

Physically, this method is based on the fact that (for example for ozone in the UV) the penetration depth of radiation is a function of wavelength. Because of this, and due to the temperature dependency of the absorption, altitude information is contained in the measured nadir spectra. The principle idea to retrieve this information is illustrated in Figure 6.

The FURM algorithm consists of two parts: A radiation transfer model is used to calculate the radiance for the given geometry and a specific atmospheric state. Then an inversion scheme matches in iterative steps this calculated radiance to the measured spectra by modification of atmospheric parameters.

In the end, this process reveals height-resolved information about the distribution of trace gases; however, the calculation is rather time-consuming, and also a-priori climatological information is required. FURM is only applicable for strong absorbers like ozone and for the same reason gives only limited vertically resolved information about the troposphere.

This approach has been successfully used for case studies with GOME data (see Beek et al., 1997), using the radiation transfer model GOMETRAN (Rozanov et al., 1997, 1998) in combination with an inversion scheme based on the optimal estimation method (Rodgers, 1976).

5.3 Limb and Occultation Profiles

The algorithms for the retrieval of vertical profiles from limb or occultation geometry are currently being developed, the basic ideas will be given here.

The most accurate method is the 'global fitting' approach. The concept used in 'global fitting' is to iterate modelled radiances to match the measured values simultaneously for all atmospheric layers. In this sense, 'global fitting' is quite similar to FURM, with the difference that limb or occultation geometry is used instead of nadir data.

Another possible method is the 'onion peeling' approach which computes the vertical column for each individual layer starting from the top of the atmosphere. This will most likely be done by scaling appropriate reference spectra obtained from radiative transfer model calculations. The column of the lower layers is computed the same way by subtracting the upper columns. 'Onion peeling' is probably faster than 'global fitting' but less favoured because contributions to the measured spectrum from altitudes below the tangent height are not considered. Thus, 'onion peeling' is certainly not adequate for limb measurements, and its feasibility for occultation measurements has to be investigated.

Limb and occultation measurements will result in atmo-

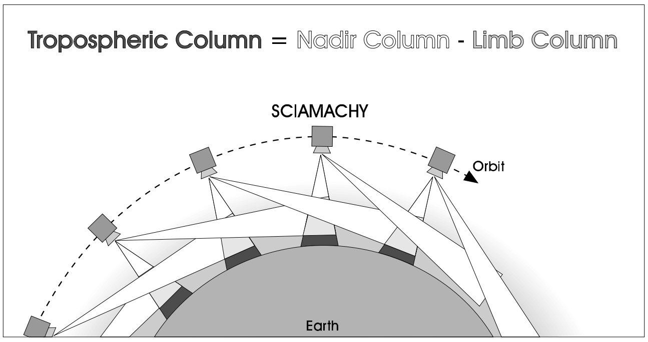

Fig. 7. Derivation of tropospheric columns from combined limb and nadir measurements.

spheric trace gas profiles with high vertical resolution. Solar occultation measurements are expected to have a high precision due to the high intensities of the incoming light and the comparably simple observational geometry.

Major problems arise from the fact that a full spherical geometry has to be considered. For limb it is also necessary to take multiple scattering into account. A radiative transfer model for limb and occultation geometry with appropriate features is currently under development in Bremen.

5.4 Tropospheric Columns

It is quite unlikely that tropospheric information can be drawn directly out of limb or occultation measurements, because the presence of clouds will inhibit insight to the troposphere in most cases. On the other hand, the vertical resolution of profiles derived from nadir measurements is not sufficient to derive tropospheric columns with an acceptable precision. Nevertheless, this will be possible by the combination of limb and nadir measurements.

The principle idea is to subtract the stratospheric/mesospheric/upper tropospheric column derived from limb measurements from the total column derived from subsequent nadir measurements of the same atmospheric volume. This is illustrated in Figure 7.

This residual technique was developed by Fishman et al. (1990, 1996) for the derivation of tropospheric ozone columns from the combination of TOMS total nadir columns with SAGE II occultation profiles or SBUV nadir profiles.

Retrievals using the combination of nadir and limb measurements are foreseen for the SCIAMACHY mission and result in several advantages. The most striking features of SCIAMACHY in this context are that all measurements are performed with the *same instrument*, and that the timing of measurements is such that almost the *same atmospheric volume* is first viewed in limb and then after only a *short time delay* of about 8 minutes in nadir geometry (see Figure 7). Furthermore, alternating limb/nadir measurements are performed for most of the orbit (see Figure 4) thus providing *global coverage* within 6 days. Last but not least, the derivation of tropospheric columns is possible *not only for ozone* but also for NO_2, CO, CH_4, H_2O, N_2O, SO_2, H_2CO, and BrO.

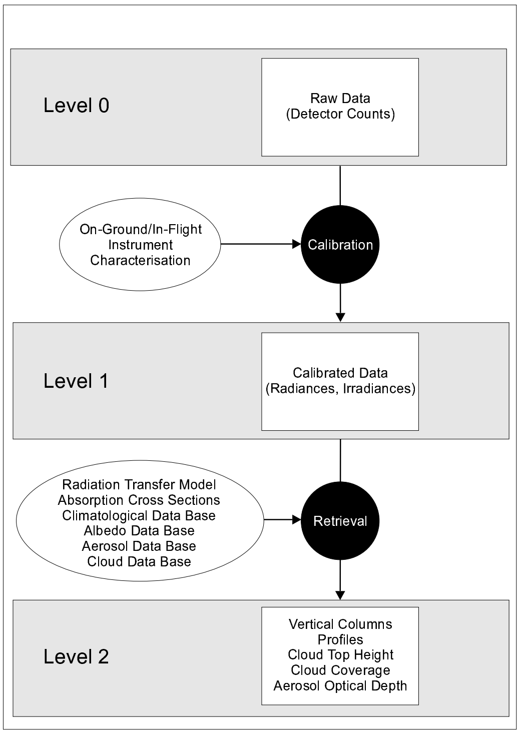

Fig. 8. SCIAMACHY product Levels 0 to 2.

6 Expected Results

6.1 Operational Products

As can be seen in Figure 8, SCIAMACHY products are organised in different levels. Level 0 data (raw data, i.e. detector counts) are calibrated using the instrument characterisation data base obtained from both on-ground and in-flight measurements. This results in radiance and irradiance spectra, the so-called Level 1 data.

In a next step, a retrieval algorithm is used to obtain information about atmospheric constituents, such as vertical columns and profiles of trace gases, cloud top height, cloud coverage and aerosol optical thickness. This requires a radiative transfer model, appropriate absorption cross sections, and a climatological data base which contains information about albedo, aerosol and clouds. The resulting Level 2 product may be further processed to higher-level products, such as global maps of trace gas columns, etc.

Figure 9 lists all operational Level 2 products of SCIAMACHY, i.e. all profiles and column densities of atmospheric constituents which are regularly processed, quality controlled, and archived. This list resembles the recommendations of the SCIAMACHY Science Advisory Group and thus also includes some products for which implementation in the on-ground processor is currently under negotiation with the agencies.

The data products are divided into Near Real-Time and

	Nadir Total Column Amount			Limb Stratospheric Profile		
	UV/Vis	IR	UV to IR	UV/Vis	IR	UV to IR
Near Real-Time	O_3 NO_2 OClO * SO_2 * H_2CO * BrO **	H_2O N_2O CO CH_4 #	Clouds Aerosol			
Off-Line	O_3 NO_2 BrO OClO * SO_2 * H_2CO * UV Index**	H_2O N_2O CO CO_2 CH_4 Pressure Temp.	Clouds Aerosol	O_3 NO_2 BrO**	H_2O CO_2 CH_4 Pressure Temp. N_2O** CO**	Aerosol

*observed under special condition
(volcanic eruption, ozone hole, heavy tropospheric pollution)

#reduced quality at CO fitting window

**recommended by Science Advisory Group,
implementation under negotiation with agencies

Fig. 9. SCIAMACHY Level 2 operational products. Additional scientific products for process studies from occultation and limb measurements are planned.

Off-Line products. Near Real-Time data products will be available within a few hours after the measurements. Near Real-Time processing will employ look-up tables for radiative transfer rather than operational running of the models.

Off-Line data products will be produced using improved ancillary data that become available after spectrum acquisition, e.g. analysed temperature and pressure fields.

Ozone, NO_2, BrO, H_2O, N_2O, CO, CH_4, cloud and aerosol information as well as atmospheric pressure and temperature will be available on a global grid. Other products (OClO, SO_2, H_2CO) will only be observed under special conditions, such as volcanic eruptions, ozone hole conditions, or heavy tropospheric pollution.

Please note that additional scientific products for process studies from occultation and limb measurements are planned. This includes also the retrieval of tropospheric information from combined limb/nadir measurements.

6.2 Precision Estimates

Several sensitivity studies have been performed to estimate the precision of the SCIAMACHY products. As these are described in Bovensmann et al. (1999) only some highlights are mentioned here:

The precision of nadir total columns for O_3 and NO_2 is expected to be higher than 1% and 2%, respectively. Vertical profiles for O_3, BrO, and (under ozone hole conditions) OClO obtained from solar occultation measurements will have a precision of 1%, 5%, and 2%. The combination of limb and nadir measurements will yield tropospheric columns of ozone, NO_2, and CO with an precision of 10%; since most of the CH_4 is located in the troposphere a precision of even 5% is expected in this case. Throughout the SCIAMACHY mission, extensive validation activities are planned to assure the data product quality.

7 Summary & Current Status of Project

SCIAMACHY is a space-based spectrometer designed to measure sunlight, transmitted, reflected and scattered by the Earth's atmosphere or surface in the ultraviolet, visible and near infrared wavelength region (240 nm – 2380 nm) at moderate spectral resolution (0.2 nm – 1.5 nm).

The absorption, reflection and scattering characteristics of the atmosphere are determined by measuring the extraterrestrial solar irradiance and the upwelling radiance observed in nadir, limb, and occultation viewing geometry. The ratio of extraterrestrial irradiance and the upwelling radiance can be inverted to provide information about the amounts and distribution of important atmospheric constituents, which absorb or scatter light, and the spectral reflectance of the Earth's surface.

SCIAMACHY was conceived to improve our global knowledge and understanding of a variety of issues of importance for the chemistry and physics of the Earth atmosphere (troposphere, stratosphere and mesosphere) and to investigate potential changes resulting from either anthropogenic behaviour or natural phenomena. Stratospheric ozone, tropospheric pollution arising from industrial activity and biomass burning, troposphere–stratosphere exchange and special events such as volcanic eruptions, solar proton events, and other related regional and global phenomena are the main objectives of the SCIAMACHY mission.

SCIAMACHY measurements will yield the amounts and distribution of O_3, BrO, OClO, SO_2, H_2CO, NO_2, CO, CO2, CH_4, H_2O, N_2O, pressure, temperature, aerosol, radiation, cloud cover and cloud top height.

A special feature of SCIAMACHY is the combined limb/nadir measurement mode, by which tropospheric information about several trace gases can be derived. SCIAMACHY is thereby able to detect tropospheric column amounts of O_3, NO_2, CO, CH_4, H_2O, N_2O, SO_2, H_2CO, and BrO down to the planetary boundary layer under cloud free conditions or to the cloud top.

Depending on the type of measurements to be performed during the orbit, global coverage is achieved within 3 or 6 days.

SCIAMACHY will be part of the atmospheric payload of the ESA satellite Envisat-1 which is planned to be launched in late 1999. The current status of the SCIAMACHY project is such that the manufacturing phase of the instrument has been almost completed. The calibration period will start soon.

SCIAMACHY will provide new insight into the global behaviour of the troposphere and the stratosphere. Because of its wide range of applications SCIAMACHY is a good candidate instrument for any future global monitoring system.

Table 1. WWW Information Sources

Satellite/Instrument	Link
Envisat-1 (incl. instruments)	http://envisat.estec.esa.nl/
GOME/SCIAMACHY	http://www-iup.physik.uni-bremen.de/
IMG	http://www.eoc.nasda.go.jp/guide/guide/satellite/sendata/img_e.html
MAPS	http://stormy.larc.nasa.gov/press.html
MOPITT	http://www.atmosp.physics.utoronto.ca/MOPITT/home.html
SAGE II	http://www-arb.larc.nasa.gov/sage2/
TES	http://tes.jpl.nasa.gov/

Appendix Web Sites

Further and actual information about the satellite sensors mentioned in the text may be obtained from the world-wide-web sites listed in Table 1.

Acknowledgements. SCIAMACHY is a national contribution to the Envisat-1 mission funded by the German (DLR-Bonn, formerly DARA GmbH) and Dutch (NIVR) space agencies, including a Belgian (IASB) contribution. The SCIAMACHY industrial consortium comprises the prime contractors Dornier Satellite Systems (D) and Fokker Space (NL) and the subcontractors OHB-Systems (D), Jenoptik (D), SRON (NL), TPD-TNO (NL), OIP (B) and EPITAXX (USA). The instrument and algorithm development is supported by the activities of the SCIAMACHY Science Advisory Group (SSAG), a team of scientists from various international institutions: University of Bremen (D), SRON (NL), SAO (USA), IASB (B), MPI Chemistry Mainz (D), KNMI (NL), University of Heidelberg (D), IMGA (I), CNRS-LPMA (F). Operational data processing is to be performed by DLR-DFD within the Envisat ground segment D-PAC. The mission operation is supported by the SCIAMACHY Operations Support Team SOST, which prepares mission scenarios, measurement strategies and instrument calibration activities. This work has been funded as part of the SCIAMACHY Scientific Support Study by the BMBF under grant 50EP9207 and the University of Bremen.

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