The SCIAMACHY Mission

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Extended abstract

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INTRODUCTION

SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY) is a 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) and high radiometric accuracy (relative < 1%, absolute < 2 - 4 %). Details of the instrument design were described elsewhere ([1], [6] and [10]).

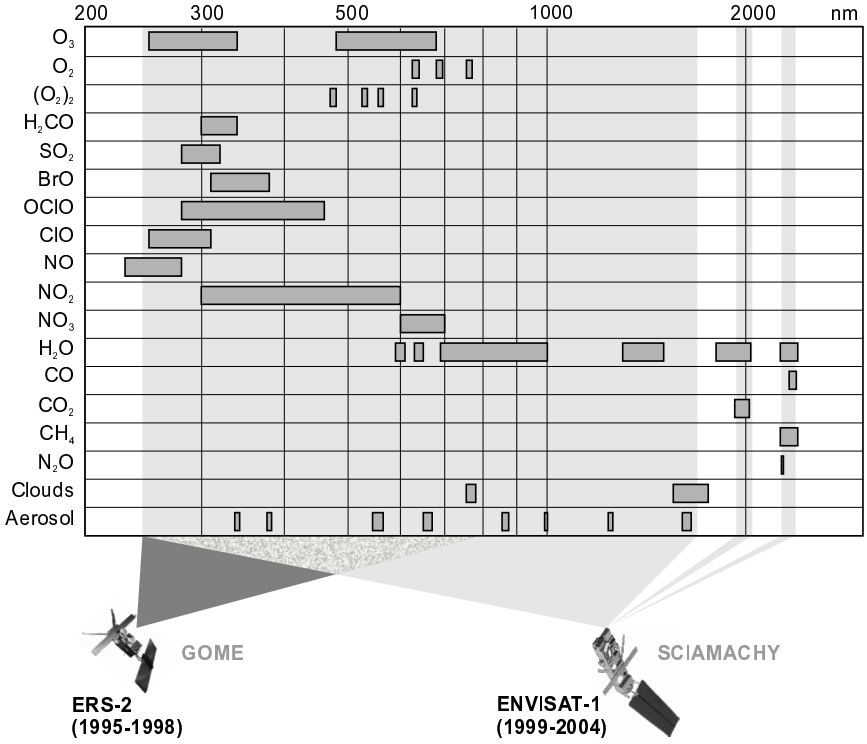

Figure 1 Wavelength range covered by SCIAMACHY and absorption windows of the targeted constituents

Inversion of SCIAMACHY measurements yield amounts and distributions of O_3, BrO, OClO, ClO, SO_2, H_2CO, NO_2, CO, CO_2, CH_4, H_2O, N_2O, p, T, aerosol, radiation, cloud cover and cloud top height from nadir, limb and occultation observations [2]. SCIAMACHY measures simultaneously and contiguously radiation in the wavelength range from 240 to 1750 nm. In addition it measures in two short infrared bands around 2.0 µm and 2.3 µm, which target the CO, CO_2, CH_4 and N_2O products. Figure 1 indicates the wavelength range covered by SCIAMACHY and the position of spectral windows where atmospheric constituents are to be retrieved.

SCIAMACHY, as well as MIPAS and GOMOS, is part of the atmospheric chemistry payload onboard the Environmental Satellite EnviSat-1 being prepared by the European Space Agency ESA. The launch is planned to be in late 1999.

SCIENTIFIC OBJECTIVES AND TARGETED CONSTITUENTS

SCIAMACHY was conceived to improve our knowledge and understanding of a variety of issues of importance for the chemistry and physics of the Earth atmosphere (troposphere, stratosphere and mesosphere) and potential changes resulting from either anthropogenic behaviour or natural phenomena such as:

- tropospheric pollution arising from industrial activity and biomass burning,
- exchange processes between stratosphere and troposphere,
- stratospheric chemistry relevant at polar regions as well as at mid-latitudes,
- mesospheric chemistry and dynamics,
- climate

From the limb and solar/lunar occultation observations, vertical distributions of the trace atmospheric constituents are derived. This provides information about the stratospheric and upper tropospheric composition. These data is required to improve our understanding of stratospheric chemistry and physics as well as exchange between the stratosphere and troposphere. The combination of the near simultaneous limb and nadir observations yields unique information about tropospheric and lower stratospheric constituents (gases, aerosol and clouds). SCIAMACHY is one of a limited number of instruments which is able to detect tropospheric constituents being of particular relevance and importance to tropospheric oxidation, such as O_3, CO and CH_4, down to the planetary boundary layer under cloud free conditions. The solar and lunar occultation measurements yield very accurate profiles of atmospheric constituents.

Figure 2 depicts the targeted constituents in the different height ranges.

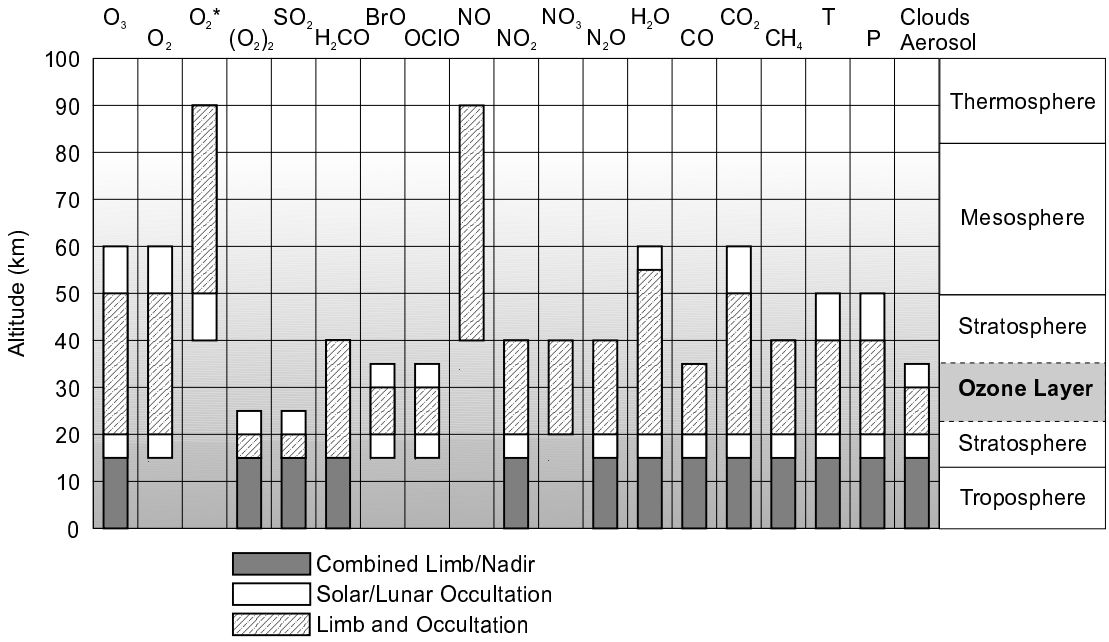

Figure 2 Altitude ranges of atmospheric constituents targeted by SCIAMACHY. Retrieval from the occultation measurements yields information over a wider altitude range than the limb measurements, due to its higher S/N.

MEASUREMENT PRONCIPLE AND RETRIEVAL METHODS

The absorption, reflection and scattering characteristics of the atmosphere are determined by measuring the upwelling earthshine radiance observed in nadir, limb and occultation geometry and the extraterrestrial solar irradiance. The ratio of upwelling radiance and the extraterrestrial irradiance can be inverted to provide information about the amounts and distribution of important atmospheric constituents, which absorb or scatter light, and the spectral reflectance (or albedo) of the Earth's surface. The amount of trace gases is determined from SCIAMACHY measurements by their absorption features. Two methods are used to invert the measurement data: the DOAS (Differential Optical Absorption Spectroscopy) technique [11] and the so called FUll Retrieval Method FURM [5] based on an optimal estimation scheme [12]. The successful retrieval of ozone profile information with FURM from GOME nadir measurements has already been demonstrated [7].

PRECISION ESTIMATES OF TRACE GAS MEASUREMENTS

From the beginning of the project several sensitivity studies were performed by members of the SCIAMACHY and the GOME Science Advisory Group and their institutes ([2], [3], [4], [5], [8], [9], [13], [14]). Table 1 represents the status of the expected precision of trace gas measurements in the different measurement modes.

	Nadir Column	**Vertical Profiles**			**Nadir - Limb**
Molecule		Occultation		Limb	Tropospheric
		Solar	Lunar		Column
O_3	~1 %	~1 %	2 %	10 %	10 %
NO_2	2 % ##	~1 %	5 %	10 %	10 %
NO_3	5 %	50 % (day)	10 % (twilight)	§	-
BrO	5 % ##	5 %	§	50 %	§
OClO&	5 % ##	2 %	5 %	§	§
ClO&	20 %	50 %	§	50 %	-
H_2CO!#	20 % ##	-	-	§	25 %
SO_2 !	10 % ##	-	-	§	10 %
H_2O	1 %	~1 %		10 %	~ 5 %
N_2O	5 %	~1 %	5 %	10 %	~10 %
CO	5 %	1.5 %		10 %	~10 %
CO_2	1 %	~1 %		10 %	~ 5 %
CH_4	1 %	~1 %		10 %	~ 5 %
NO§	20 %	~1 %		10 %	-
O_4	5 %	10 %		20 %	10 %
O_2	~1 %	~1 %		10 %	~10 %
O_2 ($^1\Delta_g$)	~1 %	~1 %		10 %	-

Table 1 Summary of the precision estimates of targeted trace gases. Note that for limb profiles the precision depends strongly on altitude. (!) polluted tropospheric conditions, (#) biogenic emissions and biomass burning, (§) estimated knowledge of column above 40 km, (&) under Ozone hole conditions, (##) feasibility of the retrieval was already shown by GOME [7], (§) scientific feasible, study necessary to determine retrieval precision.

CONCLUSIONS

SCIAMACHY represents a new generation of space based remote sounding sensors which rely on and utilize the simultaneous measurement of light upwelling from the atmosphere over wide spectral intervals to determine amounts of atmospheric constituents. SCIAMACHY will provide new insight into the global behavior of the troposphere and the stratosphere and is a good candidate instrument for any future global monitoring system. Its data is adequate for the study of a wide range of applications such as the impact of pollution, the response of the stratospheric chemistry to control strategies and the assessment of global change.

To ensure a high data quality over the mission lifetime, instrument performance will be monitored continuously and an intensive validation campaign will be performed at the beginning of the mission.

ACKNOWLEDGEMENTS

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