

The ENVISAT Atmospheric-Chemistry Mission (GOMOS, MIPAS and SCIAMACHY) - Processing Status and Data Availability

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The Atmospheric-Chemistry Instruments

GOMOS: Global Ozone Monitoring by Occultation of Stars, is a spectrometer that works in the UV, visible and near infrared wavelength ranges. The wavelength coverage allows monitoring O3, NO2, NO3 atmospheric density from Rayleigh extinction and aerosols (NIR measurements), O2 and NO2 (NIR measurements) from upper troposphere to the mesosphere. GOMOS uses the stellar occultation technique which consists of measuring a reference star spectrum above the atmosphere and subsequently the spectra of the same star as it sets through the atmosphere. When those occulted spectra (that contain absorption features caused by the presence of trace gases) are divided by the reference spectrum, the transmission obtained are the basis for the retrieval of the atmospheric constituent densities.

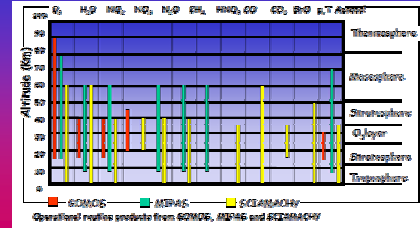


MIPAS: Michelson Interferometer for Passive Atmospheric Sounding, is a Fourier transform spectrometer that measures the atmospheric limb emission in the midIR (4.15 - 14.5 µm). It can perform elevation scan sequences through different sections of the atmosphere, from the upper troposphere to the mesosphere. MIPAS can scan in the anti-flight direction and in the perpendicular direction. It allows to retrieve profiles of several trace gases, in particular operational products include profiles of O3, H2O, CH4, N2O, HNO3 and NO2 as well as temperature and pressure, scientific products include: NO, NO2, HNO4, ClONO2, CO, CO2, CFCs, NMS, C2H6, HDO, O3 isotopomers and others (more than 25 parameters).

SCIAMACHY: is an imaging spectrometer whose primary mission objective is to perform global measurements of trace gases in the troposphere and stratosphere. The solar radiation transmitted, backscattered and reflected from the atmosphere is recorded at relatively high resolution over the range 240 nm to 1700 nm, and in selected regions between 2000 nm and 2400 nm. The large wavelength range is also ideally suited for the detection of clouds and aerosols. The three different viewing geometries (nadir, limb, and sun/moon occultations) yields to have total column values as well as distribution profiles in the stratosphere and, in some cases, the troposphere and mesosphere for trace gases and aerosols.

The ENVISAT Atmospheric-Chemistry products

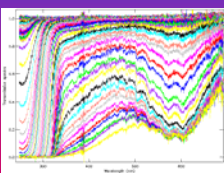
	Level 1			Level 2		
	Name	Type	Description	Name	Type	Description
GOMOS	GOM_TR_1P	NRT, off-line	Geolocated calibrated transmissions and photometer fluxes	GOM_NL_2P	NRT, off-line	Localised vertical profiles of Ozone (valid at all altitude for hot star, for cold star to be taken with care), NO2 (20 - 50 km), NO3 (20 - 45 km), Aerosol (10 - 35 km), H2O (<50 km), O2, HRP (18 - 35 km)
	MIP_NL_1P	NRT, off-line	Geolocated, spectrally and radiometrically calibrated limb emission spectra	MIP_NL_2P	off-line	Localised vertical profiles of Pressure, Temperature, Ozone, H2O, CH4, HNO3, N2O, NO2
SCIAMACHY	SCI_NL_1P	NRT, off-line	Geolocated engineering calibrated scientific measurements. The SciLc tool allows the user to apply specific calibration as for his particular needs and generates Level 1 products	SCI_O_2P	off-line	Vertical Column (Nadir) and Profiles (Limb) of Ozone, NO2, Cloud Properties (CH, CO, AAJ) (nadir only), the next baseline (mid 2009) will provide in addition operational BrO, SO2, H2O, CO Total Columns and OOD Short Columns as well as Limb BrO Profiles and Limb PSC/NLC products.



Processing Overview

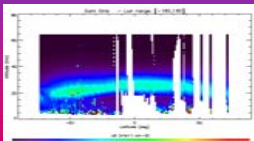
Level 1 processing

The aim of the Level 1 processing is to estimate a set of horizontal transmission functions in the UV-visible and near IR range from 250 nm to 950 nm using data measured by the GOMOS spectrometers. There are two types of Level 1 products: the geolocated and calibrated transmission spectra products (GOM_TR_1P) and the geolocated and calibrated background spectra limb products (GOM_NL_1P).



Level 2 processing

The input data needed for the Level 2 processing are the transmission from the Level 1 products and relevant auxiliary data. The aim of the Level 2 processing is to retrieve the vertical profiles of O3, NO2, NO3, O2, H2O and other trace gases profiles, the aerosol extinction coefficient and wavelength dependency parameters, and the High Resolution Temperature from the photometer signal. There are three types of Level 2 products: the products storing the profiles of temperature and atmospheric constituents (GOM_NL_2P), the residual extinction products (GOM_EXT_2P) and the products storing only profiles processed in NRT for metro users (GOM_NRT_2P).

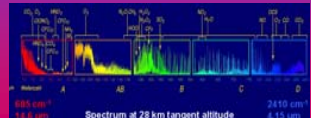


MIPAS

Level 1 processing

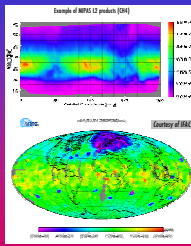
For MIPAS, the output of the L1B processor is an atmospheric spectrum (see example below) showing radiance as a function of wavenumber. Three types of calibration are required:

- Radiometric calibration:** the process of assigning absolute values in radiance units, $(W/(m^2 \cdot sr \cdot cm^{-1}))$ to the intensity axis (y-axis) with a specified accuracy.
- Spectral calibration:** the process of assigning absolute values in cm^{-1} to the wavenumber axis (x-axis) with a specified accuracy.
- Line of Sight (LOS) calibration:** the process of assigning an absolute LOS pointing value to a given atmospheric spectrum with a specified accuracy.



Level 2 processing

The operational Level 2 analysis determines, from the level 1b calibrated spectra, the geophysical parameters of interest. This includes the pressure and temperature at tangent altitudes and the vertical profiles of six species selected to have highest priority, namely: O3, H2O, CH4, HNO3, N2O and NO2. The retrieval is extended in the altitude measurement range spanned by the MIPAS measurement. See example of L2 results for CH4 on the plot on the right.



SCIAMACHY

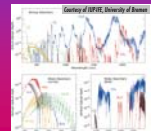
Level 1 processing

SCIAMACHY level 0 data is converted into "calibrated radiance" level 1b products by applying calibration algorithms and calibration parameters, for details see also: http://atmos.odl.itd.fr/projects/scp/sciamachy_book/sciamachy_book.html

There are two major groups of calibration parameters:

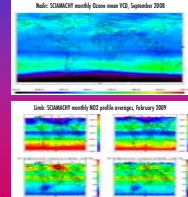
- Pre-flight instrument calibration data, the so called Key Data
- In-flight calibration measurements: (i) Lookup Current Calibration, (ii) Solar Reference Calibration, (iii) Spectral calibration, (iv) Nadir-Point-Gain (PPG) and Eddon

 The science users can transform the Level 1b products into fully calibrated Level 1c products with the SciLc tool (<http://envsat.esa.int/sci/lc/>), selecting specific calibrations and extract for certain geographic areas, time intervals, spatial regions and measurement type of interest. The latest SciLc version includes also the possibility to correct the data for degradation with the factor correction.



Level 2 processing

The level 2 off-line products are derived from consolidated level 1b calibrated spectra. SCIAMACHY operational products are divided in Limb and Nadir products. Currently O3 and NO2 profiles and Vertical Column Densities as trace gases are operationally processed as well as cloud products. Besides the operational SCIAMACHY products a number of scientific products are available: developed at different institutes and an overview is provided at <http://www.sciamachy.org>. The Level 2 off-line processor will also be used for the generation of Fast Delivery Level 2 products with the next processor version in mid 2009. In this way ESA Level 2 products will be available within 24 hours from acquisition including limb data.



Processing Status

The current processor software version for the operational ground segment is GOMOS_V5.00 since 8th August 2006. The product specification is PO45-MMA-652009_10_31. This processor has been cleared for level 1 data release, with a disclaimer for known artifacts (<http://envsat.esa.int/datasets/availability/disclosures/>) that are currently being resolved and will be implemented in following releases of the processor (<http://envsat.esa.int/datasets/availability/>). See a summary of current processor status on the table below.

Reprocessing status

The improvement of the GOMOS processing chain is a continuous on-going activity performed by the GOMOS Working Group (QWG), not only for the processing algorithm but also for the instrument characterization data. In order to provide the best quality products to the users and data to the normal duty between algorithm specification and implementation in the operational PDS, it was decided to reprocess the GOMOS data using the GORP prototype developed and operated by AON. The second reprocessing activity covering years 2002-2006 (until 4th July 2006) using the prototype GORP_6.0_6.0_6.0 (corresponding to the operational processor version 5.00) was completed. All reprocessed data can be accessed from DPAC <http://gmo2005/ftp-ops.data.esa.int/> or <http://www.esa.int/gmo/index.jsp>. The third reprocessing will start as soon as the processor baseline is stable, which should be not later than end of this year 2009. See a summary of the reprocessing status on the table on the right.

The MIPAS mission can be divided into two periods: the Full Resolution (from launch up to March 2004) and the "Optimized Resolution" (from Jan 2005 onwards) missions. The "w" mission is characterized by a lower spectral resolution, but a finer vertical and horizontal grid. The changes of the Level 2 algorithm needed to cope with the new mission scenario are implemented on the prototype reference processor (m2pp v5.0), while the operational processor available in the ground segment (PF 4.67) is currently not able to process this dataset up to Level 2. The PF 4.67 is activated on NRT and off-line centers for the production of MIPAS L1 products. The production of Level 2 data will be resumed NRT and off-line as soon as the new PF 5.01 will be delivered, when the PF will be available a full mission reprocessing will be also performed. Further details on the processing configuration and status for MIPAS are presented in the table on the right.

Reprocessing status

Full Resolution mission: Level 1 and Level 2 products were reprocessed with PF version 4.61 - 4.62. All reprocessed data are available via ftp, details on how to access the data are available at: <http://earth.esa.int/datasets/availability/awnoaccess.html>

Optimized Resolution mission: Level 1 products are routinely processed with PF 4.67 (4.65 before Sep 2006) and available NRT (ESON and Karna) and off-line (DPAC). Level 1 and Level 2 products of some selected validation orbits were processed with the prototypes, aligned to the baseline of the future PF 5.01. These data are available at DPAC ftp server.

The current SCIAMACHY processor software version for the operational ground segment is version 6.02 for level 1b and version 3.01 for off-line versions level 2. Known artifacts are described in the "Reprocessing status" disclaimer (<http://envsat.esa.int/datasets/availability/disclosures/>) that are currently being resolved and will be implemented in following releases of the processor (<http://envsat.esa.int/datasets/availability/>). See a summary of the current processor status on the table on the right.

Reprocessing status

The improvement of the SCIAMACHY processing chain is a continuously on-going activity aiming to improve existing processing algorithms and include new trace gases in the data products. The successful implementation of the updated processor version is generally followed by a full mission reprocessing.

The SCIAMACHY second reprocessing activity was completed in early 2008. All reprocessed data are available via ftp, details on how to access the data are available at: <http://earth.esa.int/datasets/availability/awnoaccess.html>

Data products were quality checked via Daily Quality Check Reports published at: http://earth.esa.int/scp/amsat/sciamachy/reports/daily/level_2

The third reprocessing will start after the new processor become operational in mid 2009 and the successful validation is completed, expected before the end of this year 2009.

Validation Results

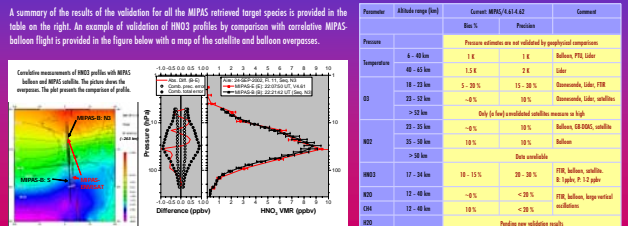
The geophysical validation is an activity that is expanded throughout the instrument lifetime. Its goal is both to characterize the instrument degradation impact on the products quality and to verify that new processor versions bring the expected improvements to the products. ESA guarantees these validation activities through different contracts, like the multi-STEP and VALID projects coordinated by BRM and BVM, exploiting data from the Network for the Detection of Atmospheric Composition Change (NDACC) and Southern Hemisphere Additional Ozonesondes (SHAZOS). The current quality status of GOMOS validation is summarized in the table below. The main improvement in the next processor version is in the H2O profiles and the error estimation. A verification of GOMOS ozone profile data processed with the new "baseline 2008" version has been performed.

- The result of the comparison of Ozone profiles with ozone sonde stations (figures below) is quite similar to the validation results shown in the table to the right for the current version.
- Ozone profiles dispersion is smaller than for the current version
- More realistic H2O profiles (shape and values)

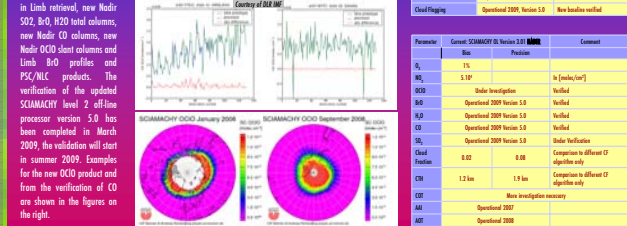
Parameter	Altitude range (km)	Current GOMOS_V5.00	Comment
O3	18-22	[1.5-1.5]	20%
	22-26	[2.4-1.6]	10%
	26-31	[0.1-1.5]	[1.5-10%]
	31-45	[1.4-0.5]	
	45-50	10%	20%
NO2	18-25	10%	20%
	25-35	10%	20%
Aerosol	18-25	2%	10% to 100%
	25-35	4%	14%
O2	25-35	0%	10%
	35-45	10%	20%
H2O	18-25	10%	40%
	25-35	10%	60%
Temperature (NRT)	18-30	Not sufficient quality for validation	Applicable quality only for days 1, 2, 3, 4, 11, 14, 16, 20 and 22
		Not sufficient quality for validation	Accuracy depends on altitude of sondes

The results of the validation of MIPAS L2 data are detailed in the ACP special issue for MIPAS. Considering the two main targets (1 and 03) we have the following validation results:

- Temperature: the validation was carried-out by comparison with correlative measurements made by radiosondes, lidar, in-situ and remote sensors operated either from the ground or stratospheric balloons. The results of the inter-comparison indicate that the bias of the MIPAS profiles is generally smaller than 1 or 2K depending on altitude.
- Ozone: the validation was based on the comparison with correlative data of ozone sondes, ground-based MIPAS, FIR and microwave radiometers, remote sensing and in situ instruments on board stratospheric aircraft and balloons, concurrent satellite sensors and ozone fields assimilated by ECMWF. A major good agreement was found between 50 hPa and 1 hPa, where the mean relative difference are within 14% and no apparent bias was observed. Below 20 hPa, a degradation of the agreement is observed, with the appearance of biases from 5% to ~25% at 100 hPa and standard deviation larger than the combined random errors by a factor of 1.5 to 3.0 in the range 50-100 hPa. No quantitative validation was possible above 50 km.



The geophysical validation is a continuous activity throughout instrument lifetime in order to improve the quality of the products. For SCIAMACHY the scientific validation is performed by a wide group of scientists, SCIAMACHY, representing the specialists for the different data products <http://www.sciamachy.org/validation/>, who are comparing the data with those from validation campaigns from ground-based balloons, aircraft or satellite instruments measurements. The current quality status of the ESA operational SCIAMACHY product validation is summarized in the tables to the right. The next processor version foresees changes on the NO2 retrieval settings, new AL algorithm, improvements in Limb retrieval, new Nadir SO2, BrO, H2O total columns, new Nadir O3 total columns, new Nadir O3 total columns and Limb BrO profiles and PSC/NLC products. The verification of the updated SCIAMACHY level 2 off-line processor version 5.0 has been completed in March 2009, the validation will start in summer 2009. Examples for the new O3O product and for the new verification of CO are shown in the figures on the right.



Source of info

Data quality disclaimers provide information on known deficiencies in processing, and on transient degradations not yet compensated <http://envsat.esa.int/datasets/availability/disclosures/>. The scientificity interests of the ENVISAT instrument are available on line <http://envsat.esa.int/instruments/scientificity/>. For any questions on ENVISAT and/or on accessing atmospheric products, please contact ESA's SO Helpdesk sohelp@esa.int

ENVISAT Daily/monthly reports, inform about calibration and processing configuration, anomalies, degradation, and performance, they can be accessed for the atmospheric chemistry missions at: <http://earth.esa.int/scp/amsat/mipas/reports/>, <http://earth.esa.int/scp/amsat/gomos/reports/>, <http://earth.esa.int/scp/amsat/sciamachy/reports/>

