ENVISAT-MIPAS: Instrument Commissioning & Early Results

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Abstract - The Michelson Interferometer for Passive Atmospheric Sounding forms part of the atmospheric payload on board ESA's polar orbiting Envisat, launched on 1 March 2002. It is going to sense the Earth's limb emission in a broad spectral range in the thermal infrared, allowing to detect a large number of atmospheric trace gases in a height range from the upper tropopause up to the lower mesosphere.

Primary activities during the initial four weeks of in-orbit operation include the verification of the instrument's health status and its communication with the ground segment. The subsequent CalVal phase comprises various special calibration measurements, with a focus on radiometric and spectral characterisation, as well as the line-of-sight pointing accuracy. Moreover, dedicated analyses will be carried out in order to validate critical components of the on-ground Level 1B and Level 2 processing stages and to optimise primary algorithm settings.

I. INTRODUCTION

MIPAS, one of the atmospheric sensors on board Envisat, has been designed to acquire global measurements of the Earth's limb emission in an altitude range from approx. 6 km to 68 km. Based on the Fourier transform measurement technique it provides coverage of a broad spectral range, from 685 - 2410 cm\(^{-1}\) (\(\lambda = 14.6 \ldots 4.15\) micrometers), at simultaneous high spectral resolution (0.03 cm\(^{-1}\)) thus permitting unprecedented observations of a large number of middle atmospheric species. The Envisat ground segment concept foresees routine processing and dissemination of calibrated, geolocated limb spectra (Level 1B products) and of so-called Level 2 data products. The latter comprise vertical profiles of atmospheric pressure (p), temperature (T) and volume-mixing-ratio (VMR) profiles of the primary target species, O\(_3\), H\(_2\)O, CH\(_4\), N\(_2\)O, HNO\(_3\), and NO\(_2\).

Since Envisat's successful launch into a sun-synchronous, polar orbit on 1 March 2002 the instrument has undergone a variety of functional checks that aim at the verification instrument's overall health status, its commandability and the data downlink. The subsequent calibration/validation (CalVal) phase, to be conducted in the period 1 ... 9 months after launch, will be accompanied by dedicated measurements in order to verify or re-assess key instrument performance parameters. Examples are the re-characterisation of detector non-linearity, the instrument lineshape and of systematic line-of-sight mispointing. Once a stable in-orbit measurement scenario has been established checks of critical on-ground algorithms will be performed, in order to identify necessary corrections to processor components and to compile error budgets. Non-Envisat measurements of MIPAS' geophysical products, as collected during dedicated campaigns, will be taken into account. Such measurements involve a variety of sensing techniques, including ground-based, aircraft and balloon-borne instruments.

This paper shall provide an overview of the MIPAS measurement concept and of its principle Ground Segment elements. An outline of the early in-orbit calibration / validation activities will be given.

II. INSTRUMENT DESIGN & MEASUREMENT TECHNIQUE

A. Instrument

The MIPAS instrument is based on a dual-slide interferometer in conjunction with a front-end telescope optics, steerable in both elevation (vertical) and azimuth pointing direction. By means of the azimuth scan mirror the line-of-sight viewing range can be selected between a rearward (anti-flight) and sideways (anti-sun) domain. Fig. 1 provides a view of the optics module, with the side and aft viewing baffles visible.

The focal plane system houses a set of eight Hg:Cd:Te detectors which, together with their foreoptics, are located at the two output ports of the interferometer and are cooled to 70 K by means of a Stirling-cycle cooler. A simplified view of

Fig. 1. MIPAS optics module, with side and rearward viewing baffles visible
MIPAS’ functional components is shown in Fig. 2. A more detailed description of the instrument design is provided in [1].

Fig. 2. MIPAS functional components (schematic view)

B. Measurement principle

During nominal operation MIPAS will sense the atmospheric limb while the instrument’s line-of-sight (LOS) is periodically varied in discrete steps, within a tangent height range of ~6 km ... 68 km. For each height step a single interferometer stroke (‘sweep’) is performed whilst interferograms are recorded in the five spectral bands, A: 685 - 970 cm⁻¹, AB: 1020 - 1170 cm⁻¹, B: 1215 - 1500 cm⁻¹, C: 1570 - 1750 cm⁻¹, D: 1820 - 2410 cm⁻¹. Assuming a sweep measurement time of ~4.45 s (high resolution, max. path difference = 20 cm), 16 tangent heights per scan and an orbit period of 100.6 minutes, typically 80 complete elevation scans will be acquired during each orbit. Scene measurements are interleaved by periodic radiometric offset (‘deep space’) measurements. In addition, radiometric gain measurements, comprising sequences of blackbody and deep space measurements, will be performed in approx. one week intervals. With an average data rate of approx. 420 kbit/s a total of 320 MBytes of raw data will be collected in each orbit.

A summary of observational parameters and performance data is supplied in Table I.

II. DATA PROCESSING & CALVAL STRATEGY

A. On-ground data processing

The instrument data will be recorded on board and down-linked once per orbit to one of two receiving ground stations. Each downlinked sequence will be converted into a so-called Level 0 product, a computer readable data set which contains a time ordered series of data units (‘source packets’), together with various header and quality information. As a consequence of the down-link scenario the processing of Level 0 data to higher data products is performed on an orbit basis. The Level 1B stage performs the conversion of instrument raw data (scene, blackbody and deep space) and auxiliary data into radiometrically and spectrally calibrated, geo-located radiances. A number of supplementary parameters are computed as required for the correct interpretation of the Level 1B data. Primary functions comprise:

- Correction of detector non-linearity (for long wavelength (band A, AB, B) detectors)
- Channel equalisation and combination (band A detectors)
- Processing of radiometric gain and offset calibration data
- Calibration of scene data and correction of spectral axis assignment (spectral calibration)
- Computation of geolocation parameters.

The Level 2 processing is based on the analysis of emission features of selected target gases from the Level 1B input data and is performed in two stages, (1) retrieval of pressure, temperature profiles and (2) sequential retrieval of volume mixing ratio (VMR) profiles for the target species O₃, H₂O, CH₄, N₂O, HNO₃ and NO₂, using the pressure and temperature information retrieved in the first stage. The implemented algorithm is based on the so-called Global Fit approach which is defined in further detail in [3], [4].

B. MIPAS calibration & validation activities

During the CalVal phase which will span an initial period of 9 months after launch a number of specific measurements and corresponding analysis tasks will be carried out. These activities can be grouped according to:

- initial performance verification, update of instrument configuration & calibration scenario
- tasks related to Level 1B algorithm characterisation & verification
• tasks related to Level 2 related characterisation & verification
• geophysical validation of MIPAS products by comparison with non-ENVISAT correlative data (work will be part of the Atmospheric Chemistry Validation Team (ACVT) project).

A summary of envisaged activities is provided in Fig. 3. The work will be carried out in a coordinated effort, involving scientific and industrial expert teams in Europe and in Canada ABB Bomem Inc (CA), IROE-CNR (I), U. of Bologna (I), ISM (I), FZ-IMK (D), U. of Oxford (UK), U. of Leicester (UK), DLR-IMF (D), LPM (F), IAA (E) and Astrium GmbH (D). Additional teams will contribute to the MIPAS project in the frame of the ACVT effort.

CONCLUSIONS

The MIPAS early in-flight activities comprise both instrument related functional checks and performance verification tasks as well as the characterisation and validation of the on-ground processing algorithms. The envisaged tasks will be carried out in a coordinated effort, involving various companies and research institutes.

By the time this manuscript was submitted the ‘switch-on’ activities of MIPAS were still in progress. Therefore, no definite statement on instrument performance could be given. It is, however, expected that at the time of the IGARSS 2002 conference a report on first experience gathered with MIPAS data can be given.

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REFERENCES


![Fig. 3. Overview of Early MIPAS Cal / Val Activities](image-url)