GOMOS mission 2002-2010 and beyond: instrument status, performance evolution and operational data availability

Lidia Saavedra de Miguel [1], Gabriele Brizzi [1], Angelika Dehn [1], Thorsten Fehr [2], Fabrizio Niro [1], Gabriella Scarpino [1], Gilbert Barrot [3], Miguel Canela [4], Henri Laur [2] and Pascal Lecomte [5]

(1) SERCO S.p.A, Via Sciadonna 24, 00044 Frascati, Italy
(2) ESA/ESRIN, Via Galileo Galilei, 00044 Frascati, Italy
(3) ACRI-ST, Route du Pin Montard 260, 06904 Sophia-Antipolis, France
(4) ESA/ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, Netherlands
(5) ESA Climate Office – Harwell, Didcot, Oxfordshire OX11 0QX United Kingdom

Abstract

GOMOS instrument (Global Ozone Monitoring by Occultation of Stars) is one of the three atmospheric chemistry sensors on-board ENVISAT satellite launched in March 2002. GOMOS is a spectrometer that comprises one UV-Visible channel (250-675 nm) and two near infrared channels (756-773 nm and 926-952 nm). These wavelength regions allows retrieving atmospheric vertical profiles of O_3, NO_2, NO_3, O_2, H_2O, atmospheric density and aerosols. Since the beginning of the mission, GOMOS has provided a unique dataset, mainly ozone profiles, derived by exploiting the stellar occultation technique which allows a good vertical resolution (maximum integration distance is 1.7 km) and good global coverage (many star targets measured).

In order to provide the user community with the best data quality it is crucial to perform a careful instrument and data products monitoring. Although GOMOS is a self calibrating instrument (ratios between spectra through and above the atmosphere are performed) calibration activities should be regularly performed in order to maintain the expected data quality. The IDEAS (Instrument Data quality Evaluation and Analysis Service) team reporting to ESA Data Quality and Algorithms Management Office (EOP-GQ) performs, among other tasks, instrument and data quality monitoring and routine calibration.

During the mission lifetime GOMOS has suffered a number of pointing degradation anomalies that in some cases required a tuning of selected in-flight parameters. In this paper we will show how the early detection of these pointing anomalies was essential for timely mission resumption and minimization of degraded data quality periods. In addition to GOMOS sensor monitoring, also data processor monitoring is performed by IDEAS. Data processors are designed as a compromise between maximization of information retrieved from the measurement and constraints on processing and dissemination times. This compromise is the main driver of the data quality expected from an instrument data product. We will show how IDEAS team guarantees that the instrument performances meet expectations and data quality is maintained throughout the mission.
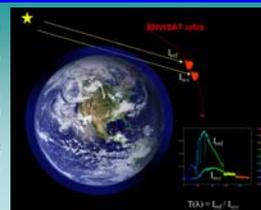
Mission overview

Mission status

★ **March 2003:** Major anomaly in Azimuth angle of the Steering Front Mechanism (SFM) → Instrument Control Unit (ICU) and Mechanism Drive Electronics (MDE) configured to side 'B' since 17-JUL-2003.

★ **January 2005:** Major anomaly affecting the Elevation angle of the SFM → Since 29-AUG-2005, a modification in the operation strategy allows to operate the instrument in an azimuth range of [-10,+10]. Afterwards, the range becomes a sliding window of 30°.

★ **End December 2008:** mirror vibrations in elevation angle during tracking phase, measured by the SATU (Star and Acquisition Tracking Unit) 'Y' axis, cause the profiles to stop high in the atmosphere and the main mission target (ozone profiling) is at risk → since 29-OCT-2009, a patch applied to the tracking controller tuning allowed mission resumption.
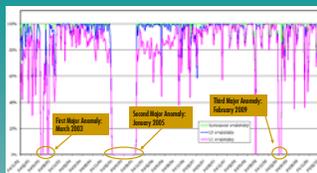
ENVISAT Mission extension beyond 2010

The main principle is to change the current altitude and inclination control (Phase E2) by altitude control only (Phase E3) in order to minimize the fuel consumption and extend the mission lifetime. ENVISAT will loose the repeat orbit track away from the equator and a drifting Mean Local Solar Time (MLST) will be induced. The new ENVISAT orbit will be implemented through an altitude decrease of 17.4 km which will be reached through different orbital manoeuvres stating on 22nd October 2010. Consequently, the ENVISAT **data flow will be suspended during the period 22nd October to 1st November 2010**. The data flow will resume on 2nd November 2010.

The GOMOS processor was adapted to handle the new orbit scenario and it was operationally switched from version GOMOS/5.00L04 to GOMOS/5.01, on 16-JUN-2010 07:24:30, orbit 43361.


Selected Orbit Control Strategy
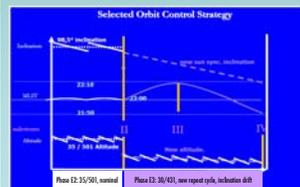
	Phase E2 (current)	Phase E3
Orbits per day	14.314	14.367
Repeat Cycle (days)	35	30
Orbits in Cycle	501	431
Orbit Period (s)	6035.928	6013.921
MLST at ascending node	22:00	21:50:00 – 22:09:28
Inclination (deg)	98.55	98.476 decreasing
Mean Altitude (km)	799.790	782.390

Phase E2: 35/501, nominal   Phase E3: 30/431, new repeat cycle, inclination drift

Instrument Monitoring

Tracking performance

The Star Acquisition and Tracking Unit (SATU) detector provides the mirror position during an occultation. The anomaly present between end December 2008 - end October 2009 caused the loss of the star measurement high in the atmosphere, which meant that many times the **corresponding ozone profiles did not include the ozone peak** present at around 25-30 km. On 29th October 2009 the upload of a patch solved this problem.

Nominal   *Anomaly*
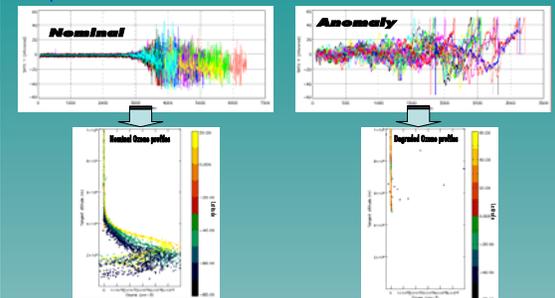
Acquisition and detection performance

★ The percentage of stars lost in detection and centering phases is less than 0.4%, much less than the warning value set to 15%.

★ The Most Illuminated Pixel (star position on the SATU CCD in detection mode) should be at the SATU center (pixel 145 in elevation, pixel 205 in azimuth). The elevation MIP was stable since the end of 2003 when the activation of a new algorithm reduced the deviations of the ENVISAT platform attitude with respect to the nominal one. The change in trend observed after the 2005 anomaly is acceptable but, at the moment, the reason is not understood.
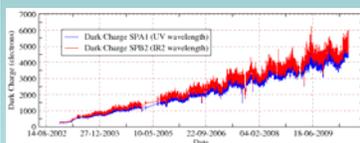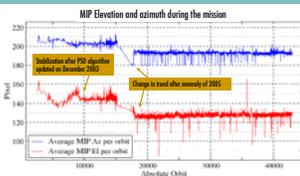

Dark Charge

Increase of the Dark Charge signal on all detectors due to non-protons radiation (expected) and due to protons (higher than expected before launch but linear in time). This increase creates problems during the retrieval of the species at least for 2/3 of the stars.

Radiometric Sensitivity

The monitoring consists of the calculation of the radiometric sensitivity of each of the four CCDs (UV, Visible, Infrared 1 and Infrared 2) and for the two photometers, by computing the ratio between parts of the reference spectrum using specific stars. For spectrometer A1 (UV) the ratio has decreased around 37% (slightly higher than expected) during the eight years of mission. This decrease is due to the expected contamination of the optics which affects mainly the UV part of the spectrum. For the other detectors the variation is much less, as expected.

-37 % in UV range
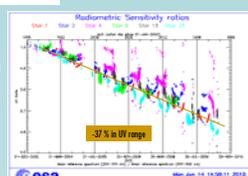
Processing/Re-processing status

The current processor software version for the operational ground segment is GOMOS/5.01 since 16th June 2010, version identical to GOMOS/5.00 (operational between August 2006 – 14 Jun 2010) but with orbit handling ready for new ENVISAT mission scenario. The product specification is PO-RS-MDA-GS2009_10_3L. This processor provides level 1 and level 2 data to the users with a disclaimer for known artifacts (http://envisat.esa.int/dataproducts/availability/disclaimers) that are currently being resolved and will be implemented in following releases of the processor (http://envisat.esa.int/dataproducts/availability). See a summary of current processor status on the table below.

|	Version	Dates	Main improvements
Operational Processor	GOMOS/5.01 (equivalent to prototype GOPR_6.0c_6.0f) (Equivalent to previous operational version GOMOS/5.00 but with orbit handling ready for new ENVISAT mission scenario starting on 22nd October 2010)	Since 08-AUG-2006	**Level 1:** ✓ Fast photometer unfolding algorithm ✓ Background correction for SPB ✓ Flat field correction improvement **Level 2:** ✓ DOAS optimization ✓ Correction of HRTP algorithm ✓ 2nd Order polynomial for aerosol ✓ Air fixed to ECMWF ✓ Orphal Cross Sections for O3
2nd Reprocessing (with Prototype)	GOPR_6.0c_6.0f (equivalent to GOMOS/5.00)	2002 → 04-JUL-2006	Same as above
Next Operational Processor	GOMOS/6.00 (equivalent to GOPR_7)	Since end 2010	**Level 1:** ✓ New reflectivity Look Up Tables ✓ New slit width function ✓ New PRNU for SPB2 (but with a fixed star position on CCD) ✓ New wavelength assignment ✓ Automatic dark charge bias correction ✓ Correction for SATU missing data **Level 2:** ✓ Full Covariance Matrix (FCM) inversion (no a-priori information) ✓ New HRTP algorithm
3rd Reprocessing (with prototype)	GOPR_7 (equivalent to GOMOS/6.00)	Whole mission	**Level 1:** Same as "Next Operational Processor" + ✓ Intra-pixel PRNU **Level 2:** Same as + "Next Operational Processor" ✓ New amplitude for FCM ✓ Error estimates computation ✓ Error estimates coding factors

Level 2 products quality

Validation results

The geophysical validation is an activity that is performed 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-TASTE and VALID projects coordinated by BIRA and RIVM, exploiting data from the Network for the Detection of Atmospheric Composition Change (NDACC) and Southern Hemisphere ADditional OZonesondes (SHADOZ). The main improvement in the next processor version is in the H_2O profiles and the error estimation. A verification of GOMOS ozone profile data processed with the next GOMOS version (GOMOS/6.00) has been performed:

★ The result of the comparison of Ozone profiles with Ozone sonde stations is quite similar to the validation results for the current version

★ Ozone profiles dispersion is smaller than for the current version

★ More realistic H_2O profiles (shape and values)

Ozone long term monitoring

Beside the validation exercises, the quality of the Level 2 data, in particular the Ozone, is routinely monitored in order to check the impact that the instrument degradation, mainly the Dark Charge increase, the azimuth range reduction and the second elevation anomaly (end 2008), has on the ozone retrievals.
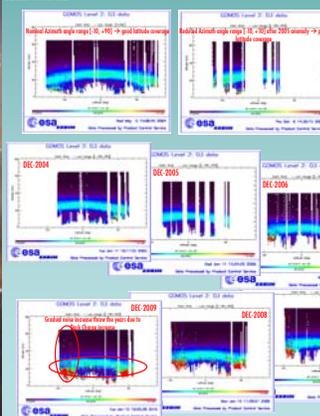
Based on this results, the reduced azimuth windows were chosen optimizing the latitude coverage

Based on this trend of increasing noise due to the Dark Charge increase, the decision of performing an annealing (a heat treatment that alters the microstructure of a material) on the detectors CCDs is being seriously considered

Users information

Instrument and data information

★ Data quality disclaimers provide information on known deficiencies in processing, and on transient degradations not yet compensated:
http://envisat.esa.int/dataproducts/availability/disclaimers/

★ The unavailability intervals of ENVISAT instruments are available on:
http://envisat.esa.int/instruments/availability/

★ For any questions on ENVISAT and for accessing atmospheric products, please contact ESA's Earth Observation Helpdesk:
eohelp@esa.int

Performance and Quality information

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/pcs/envisat/gomos/reports/
http://earth.esa.int/pcs/envisat/mipas/reports/
http://earth.esa.int/pcs/envisat/sciamachy/reports/