First scientific results on GOMOS/ENVISAT

(Invited paper)

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Abstract – **GOMOS on board ENVISAT is the first stellar occultation spectrometer providing vertical profile of ozone and minor species from the upper troposphere to the mesosphere on a regular basis. First results indicate that GOMOS will reach its expected accuracy after improvement of data processing.**

I. INTRODUCTION

The stratospheric ozone layer has been depleted during the last 30 years due to the increase of halogen species from anthropogenic origin. The photodissociation of these species in the high atmosphere liberates chlorine and bromine atoms that can be activated for the catalytic destruction of ozone molecules in presence of polar stratospheric clouds. The ozone depletion is particularly developed in the Antarctic region in early spring where the ozone hole is formed but is also observed at mid and high latitudes in the North hemisphere. Following the Montreal protocol for the limitation of emissions of halogen species, the concentration of chlorine and bromine species starts to decrease in the stratosphere and the ozone layer is expected to slowly recover during the next decades. However, due to climate global changes induced by the increase of greenhouse gases, the future evolution of the temperature in the lower stratosphere is uncertain and the recovery of the ozone layer may be delayed or accelerated. It is then of prime importance to monitor the variability and the evolution of the ozone layer with a high absolute accuracy. GOMOS instrument, on board the European satellite ENVISAT launched 1st March 2002, is dedicated to this task ([1], [2]).

It is the first space instrument dedicated to the study of the atmosphere of the Earth by the technique of stellar occultations (Global Ozone Monitoring by Occultation of Stars). From a polar orbit, it allows to have a good latitude coverage. Because it is self-calibrated, it is particularly well adapted to the long time trend monitoring of stratospheric species. With 4 spectrometers, the wavelength coverage from 245 nm to 942 nm allows to monitor ozone, H2O, NO2, NO3, air, aerosols, O2 and the temperature profiles from the upper troposphere to the mesosphere. Two additional fast photometers (1 kHz sampling rate) allows for the correction of scintillations, as well as for the determination of high vertical resolution profile. In the second part of this paper the instrument will be briefly described. In the third part data processing algorithms will be shortly presented and some preliminary results will be presented.

II. DESCRIPTION OF THE INSTRUMENT

GOMOS is based on the principle of stellar occultation. When a star sets behind the atmosphere, its light is absorbed by atmospheric constituents. Each constituent can be identified by its absorption spectrum. The atmospheric transmission spectrum is equal to the ratio between the star spectrum absorbed by the atmosphere and the reference star spectrum measured outside the atmosphere. As the reference spectrum is measured at the beginning of each occultation, we can consider that GOMOS is a self-calibrated instrument, independent of any radiometric calibration. GOMOS includes 4 spectrometers. Spectrometer A1 and A2 covers the spectral range 250 to 680 nm with a 0.3 nm sampling. It is used for the determination of O3, NO2, NO3, OClO, aerosols and atmospheric density (from Rayleigh extinction). Spectrometers B1 and B2 are centred around the absorption bands of O2 at 760 nm and H2O at 940 nm. They are of higher spectral resolution (0.05 nm). The acquisition rate is 2 Hz. This allows a vertical resolution better than 1.7 km above 40 km, improving downward to less than 1 km around 20 km due to the atmospheric refraction.

GOMOS includes also 2 fast photometers at 1 kHz acquisition rate. They have a 50 nm spectral band centred at 500 nm (blue) and 675 nm (red). They are used to correct for star scintillations induced by small scale structures in the atmospheric density.

III DATA PROCESSING AND FIRST RESULTS

Fast photometers are also used to determine a high vertical resolution temperature profile using a very innovative method :

Due to the dependency of air refractive index with wavelength, the path of the light is more bended in the blue than in the red and the same atmospheric scintillations are observed later in the blue signal. The time delay between the signal of the 2 photometers, determined by a cross-correlation technique, is proportional to the bending angle. From these measurements, it is possible to determine the vertical profile of density and temperature with a resolution better than 200 m (Figure 1).

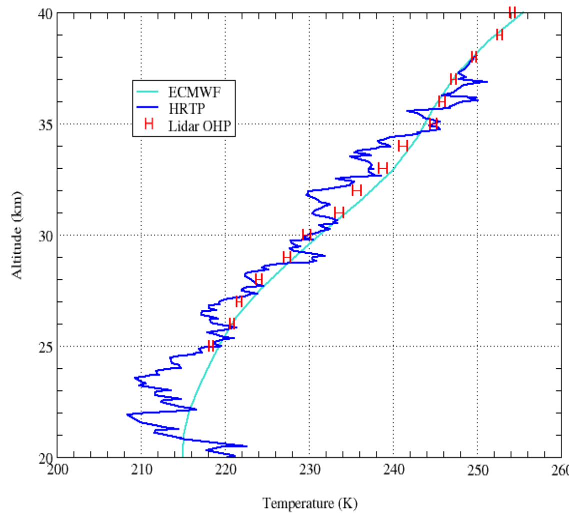

Figure 1. High resolution temperature profile compared with ECMWF and a simultaneous Rayleigh lidar profile.

The inversion of spectrometer data from Level 1b (transmission spectra) to Level 2 (vertical profiles of constituents) is made in 2 steps :

- In the nominal algorithm the spectral inversion is made globally on all retrieved species using a Levenberg-Marquardt method. It produces line densities of species as a function of tangent altitude. It works well for O_3 at all altitudes and above 40 km for minor species like NO_2 and NO_3 where scintillations do not affect the shape of the spectra.. Figure 2 presents a comparison with a lidar profiles showing a good agreement between both profiles. Below 40 km, spectra are affected by scintillations induced by small-scale turbulent structures in the atmosphere and vertical profiles of NO_2 and NO_3 line densities exhibit often large unrealistic fluctuations. In order to resolve this problem, a kind of DOAS (differential optical absorption spectroscopy) method has been developed and will be implemented in the nominal algorithm chain in the coming months. An example of vertical profiles of NO_2 line densities is shown on Figure 3. A clear gradient of NO_2 is observed between 18°S and 12°S.

- In the nominal algorithm, the vertical inversion, from line densities to local densities, is made using an onion peeling method with linear interpolation between layers. This method may induce some oscillations, especially in the bottom of the profiles where the altitude sampling is smaller due to the refraction. A Tikhonov regularization in under study. Preliminary results indicate that oscillations are greatly reduced. This method will be implemented in the nominal chain in the coming months.

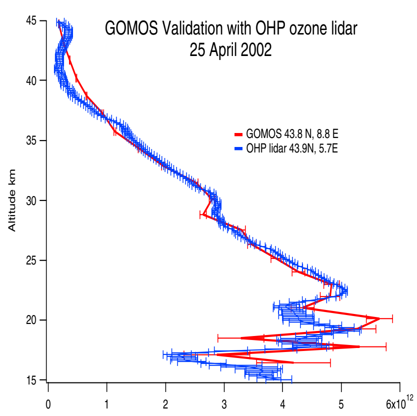

Figure 2. Vertical profiles of ozone measured simultaneously by GOMOS and the lidar at Observatoire de Haute-Provence, France.

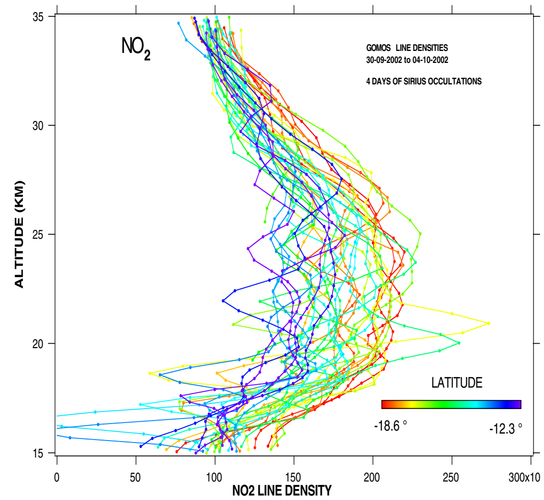

Figure 3. NO2 line densities measured versus tangent altitude for a set of Sirius occultations between 18.6°S and 12.3°S in September 2002.

IV CONCLUSION

Preliminary results obtained by GOMOS confirm that the instrument will be able to provide vertical profiles of ozone, minor constituents, aerosols and temperature with the accuracy expected before launch. However, data processing algorithms have still to be improved in order to reach this goal. As soon as it will be done, GOMOS data will be distributed to the scientific community and will be used to derive a global climatology of the measured species. They will also allow to start a number of scientific studies on atmospheric chemistry, atmospheric dynamics and climate.

REFERENCE

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