MEASUREMENT CAPABILITIES AND APPLICATIONS OF THE HIGH RESOLUTION FOURIER TRANSFORM SPECTROMETER SAFIRE-A (SPECTROSCOPY OF THE ATMOSPHERE BY USING FAR-INFRARED EMISSION - AIRBORNE)

E. Castelli(1), U. Cortesi(2), G. Bianchini(2), and B.M. Dinelli(1)

(1) Istituto di Scienze della Atmosfera e del Clima (ISAC-CNR), Via Gobetti, 101 - Bologna, Italy
E.Castelli@isac.cnr.it
(2) Istituto di Fisica Applicata "Nello Carrara" (IFAC-CNR), Firenze, Italy

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SAFIRE-A

Figure 1: The SAFIRE-A spectrometer on-board the M-55 Geophysica aircraft.

SAFIRE-A (Spectroscopy of the Atmosphere by using Far Infrared Emission - Airborne), is a passive remote-sensor capable to perform limb-sounding observations of the atmospheric emission in the Far-Infrared region (20 - 200 cm^{-1}) with a spectral resolution of 0,004 cm^{-1} unapodized [1]. The radiation from the atmosphere and from a cold or hot blackbody is collected by the input optics and analysed by a polarising interferometer; the output of the interferometer is sent to the Cold Optics and Detector Module, where it is split into two channels and, after passing through narrow-band filters (approximately 2 cm^{-1} wide), detected by photon-noise limited detectors.

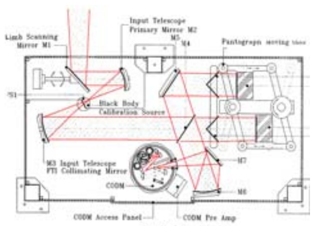

Figure 2: Schematic of the SAFIRE-A optical layout.

Instrument type	Polarising interferometer
Observation geometry	Limb sounding
Overall Dimensions	1800 x 880 x 650 mm
Total Weight	387 kg
Spectral Range	10 – 250 cm^{-1}
Max. Spectral Resolution	0.004 cm^{-1}
Number of detection channels	2
Filter bandwidth	Typically 2 cm^{-1}
Field of view	0.57°
Vertical resolution	1.5 km
Interferogram acquisition time	12, 24, 48, 96 sec
Number of spectra in a sequence	11
Spectral Signal to Noise Ratio	> 500:1

Table 1: Main instrument characteristics.

Sequences of individual spectra acquired at different limb angles are processed using an inversion algorithm specifically developed for the airborne measurements (**RAS**, Retrieval Algorithm for SAFIRE-A), to retrieve the VMR (Volume Mixing Ratio) vertical profiles of minor atmospheric constituents whose spectral features are present in the measured frequency intervals.

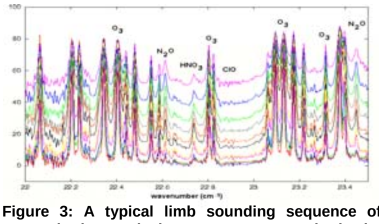

Figure 3: A typical limb sounding sequence of atmospheric emission spectra acquired by SAFIRE/A with the long wavelenght channel.

Abstract

We present here the main instrumental features, measurement capabilities and perspectives for future applications of a high resolution Fourier transform spectrometer, SAFIRE-A (Spectroscopy of the Atmosphere by using Far Infrared Emission - Airborne), that was specifically designed and built to operate onboard the high altitude aircraft M-55 Geophysica and that has already measured the atmospheric signal during more than 25 flights, as part of the M55 payload, in different test and scientific campaigns.

The most recent results are shown as an example of the level achieved by the instrument performances. Special emphasis is given to the observations carried out in October 2002 from Northern Italy, and in March 2003 from Kiruna (Artic region), with the aim of validating the level-2 products of MIPAS onboard the European satellite ENVISAT-1, since this activity is going to be one of the key task of the instrument in the short and medium term.

24.10.2002 : Mid-latitude validation flight

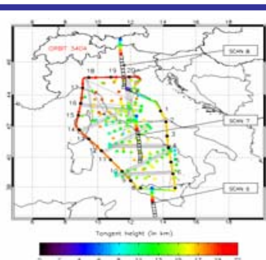

Figure 4: Map of the 24.10.2002 flight

The flight on 24.10.2002, performed from Forlì (Italy), aimed at validating MIPAS observations along the orbit 3404 (scan 6 and scan 7).

The flight route is shown in Fig. 4. Black dots indicate the average location of the aircraft during the acquisition time of each SAFIRE-A sequence, while the same colour scale has been used to represent the flight altitude and the tangent heights of MIPAS and SAFIRE-A tangent points.

MIPAS level-2 products for orbit 3404 are still unavailable, for this reason SAFIRE-A measurements of O_3, HNO_3 and N_2O profiles have been compared with MIPAS profiles from scan 3 of orbit 3418 recorded approximately at the same latitude, but ≈ 8° eastward in longitude and 24h after the flight (on 25th October 2002, ≈ h.20:50 UTC).

Results of this comparison are shown in Fig. 5. A good agreement is generally observed between SAFIRE-A and MIPAS profiles of O_3 and HNO_3. Consistent values are also found for the vertical distribution of N_2O, even if, in this case, a systematic difference between MIPAS and SAFIRE-A profiles, with MIPAS values always 10 to 20% greater.

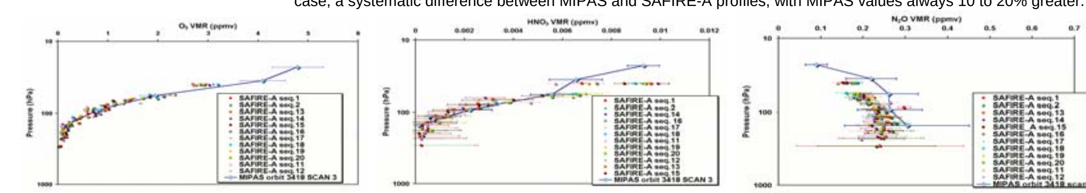

Figure 5: Comparison between O_3, HNO_3 and N_2O profiles measured by SAFIRE-A (24.10.2002) and MIPAS (25.10.2002)

02.03.2003: First Arctic validation flight

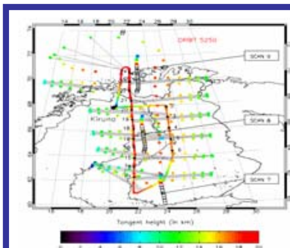

Figure 6: Map of the 02.03.2003 flight

In order to validate level-2 products of the ENVISAT chemistry instruments in presence of strong horizontal and vertical gradients five flights were planned from Kiruna (Sweden) in February-March 2003. During the flight performed on the 2nd of March 2003 the aircraft was flying across the border of the polar vortex and SAFIRE-A limb sequences were planned to sound the same air masses explored by MIPAS scans 7, 8 and 9 on the orbit 5250 (Fig. 6).

In Fig. 7 the O_3, HNO_3 and N_2O vertical distribution retrieved by SAFIRE-A are compared with the corresponding VMR profiles measured by MIPAS scan 8 approximately at the same time. The best spatial and temporal overlapping was obtained between MIPAS scan 8 and SAFIRE-A sequence 19 but additional profiles from SAFIRE-A sequences 2, 3 and 4, that were acquired at the same latitude a couple of hours earlier, are also plotted.
O_3 and HNO_3 VMR profiles agree quite well, while for N_2O MIPAS provides slightly higher values. Major differences between MIPAS and SAFIRE are located at altitudes around 100 hPa (approx. 18 km).

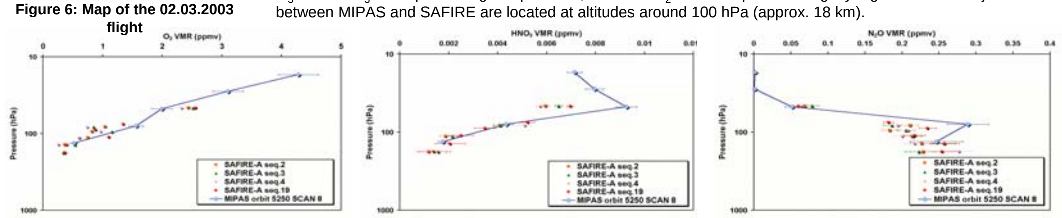

Figure 7: Comparison between O_3, HNO_3 and N_2O profiles measured on 02.03.2003 by SAFIRE-A (h ≈ 21:30 UTC for seq. 19) and MIPAS (h ≈ 20:35 UTC)

12.03.2003: Third Arctic validation flight

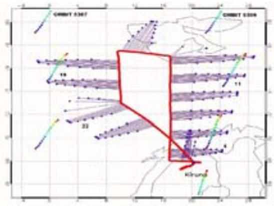

Figure 8: Map of the 12.03.2003 flight

Also on the 12nd of March 2003 the aircraft was flying across the polar vortex edge. Fig. 8 shows spatial overlapping between SAFIRE-A limb sequences and MIPAS orbit 5386 and orbit 5387.

Due to a noise problem in the recorded spectra, it was possible to retrieve only O_3 VMR profiles.

In Fig. 9 the O_3 vertical distributions retrieved by SAFIRE-A are compared with the corresponding VMR profiles measured by MIPAS. Generally O_3 profiles agree quite well, even if, for sequencences inside the polar vortex (Fig. 10), MIPAS provides slightly higher values.

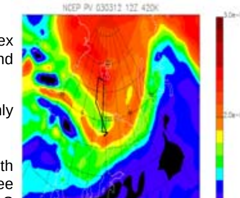

Figure 10: map of PV and M55 flight route

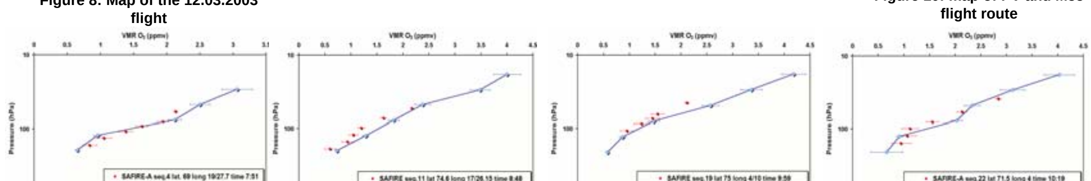

Figure 9: Comparison between O_3 profiles measured on 12.03.2003 by SAFIRE-A and MIPAS

References

1. Carli B., et al., SAFIRE-A: Spectroscopy of the Atmosphere using Far-InfraRed emission /Airborne, *Journal of Atmospheric and Oceanic Technology*, Vol. 16, p.1313, October 1999.
2. Bianchini G., U. Cortesi, L. Palchetti, E. Pascale, SAFIRE-A: optimised instrument configuration and new assessment of spectroscopic performances, submitted for publication to *Applied Optics*, May 2003.

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