MIPAS2D: 2-D analysis of MIPAS observations of ESA target molecules and minor species

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RATIONALE

Measurements from the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) [1] on board ESA ENVIronmental SATellite (ENVISAT) were analyzed with the Geo-fit Multi-Target Retrieval (**GMTR**) retrieval system [2] to create a database of **2-D fields** of pressure, temperature and Volume Mixing Ratio (VMR) of target species (MIPAS2D). Exploiting the GMTR potentialities, the analysis was operated **for the first time** on a **common** (**altitude-latitude**) **fixed retrieval grid**, to improve the combined use of modelling and observations. The MIPAS2D database which includes **pressure**, **temperature** and VMR profiles of the six main target species **H_2O**, **O_3**, **HNO_3**, **CH_4**, **N_2O** and **NO_2** from the original mission (July 2002-March 2004) is currently being extended to **N_2O_5**, **$ClONO_2$**, **COF_2**, **CFC-11**, **CFC-12** and to measurements from the new low resolution mission (up to date). The database is made available to the scientific community. Samples of the results and their applications are presented and discussed.

THE GMTR ANALYSIS SYSTEM

The GMTR is an open source code specifically designed for MIPAS measurements delivered to ESA to be included in the BEAT tools repository [3]. The GMTR inversion system is based on the Geo-fit approach [4] upgraded with the Multi-Target Retrieval (MTR) functionality [5]. The Geo-fit approach performs a 2-dimensional retrieval of the whole orbit adopting a 2-D discretization of the atmosphere which enables to model horizontal atmospheric inhomogeneities. The MTR method fits simultaneously target species that can interfere, thus eliminating the systematic error components due to the propagation of the uncertainties on p, T and on the amount of molecules that generate interfering spectral features. The advantage of the GMTR are particularly important in regions such as the polar vortex or the day-night terminator where strong horizontal gradients may be poorly reproduced by common 1-D retrievals [2].

THE LEVEL-2 DATABASE: MIPAS2D

The MIPAS2D dataset [*] includes the complete Full Resolution (FR) mission, covering the time period from July 2002 to March 2004 when MIPAS operations in the original configuration were suspended due to the deterioration of the interferometric slides. Starting from January 2005 all MIPAS observation modes have been re-defined for a new configuration in which the instrument is operated at 41% of its maximum spectral resolution. Currently the MIPAS instrument is fully operational and the mission lifetime has been extended up to 2011.

Pressure, temperature, H_2O and O_3 profiles were retrieved simultaneously with a MTR; all other targets were then retrieved in cascade, exploiting the atmospheric fields previously determined. The currently released MIPAS2D version 1.0 has been computed in the range from 12 to 68 km over a fixed vertical grid, at steps of 3 km up to 42 km height and at heights 47, 52, 60 and 68 km (MIPAS nominal mode altitudes). For some species the altitude range was limited to the region of higher signal to noise.

MIPAS2D was produced in two configurations:

NOM: on a nominal horizontal grid set at the average latitudinal coordinate of the limb-scans;

GRD: on a fixed latitudinal grid with 5 degrees steps.

Both NOM and GRD datasets were obtained adopting an optimal estimation (in order to handle observations affected by clouds) with no regularization. As *a priori* information ESA Level-2 profiles (if available) or climatological data have been used.

Geolocation information, random errors and chi-squares of the fit are provided together with the information content levels in the database.

Compared to the standard NOM retrieval mode, the GRD dataset eases the comparison with model calculations and climatological datasets with no need of interpolation along latitude. A posteriori tests proved that the two datasets are consistent and have comparable precision.

As examples of the potentialities of MIPAS2D we show some applications obtained exploiting the datasets.

- Figure 1 shows ozone VMR mean (from 1^{st} October to 10^{th} October 2003) global map at 30 km altitude.

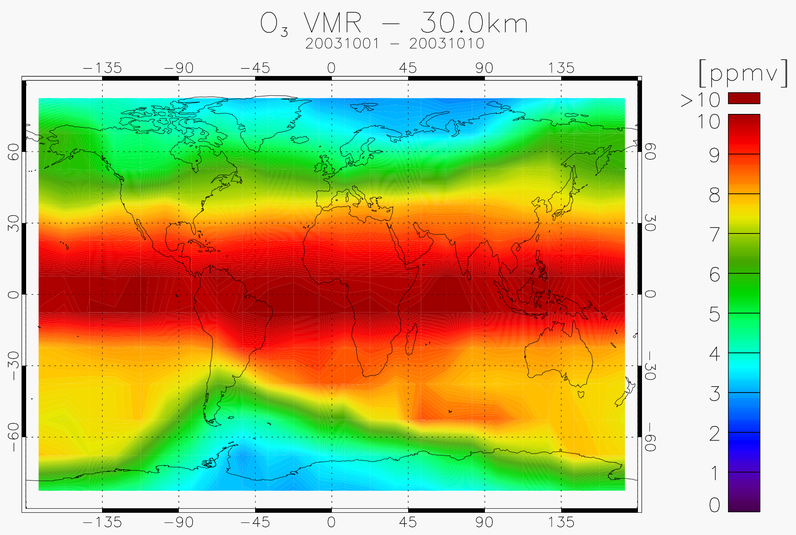

Figure 1: O_3 - 30 km mean map (1^{st} – 10^{th} Oct 2003)

NEW PRODUCTS

- Figure 2 shows examples from the NO_x family: the new N_2O_5 and $ClONO_2$ together with the primary target NO_2 VMR averages (from 1^{st} October to 15^{th} October 2003) global maps at altitudes spanning from 24 to 36 km centered on the South Pole.

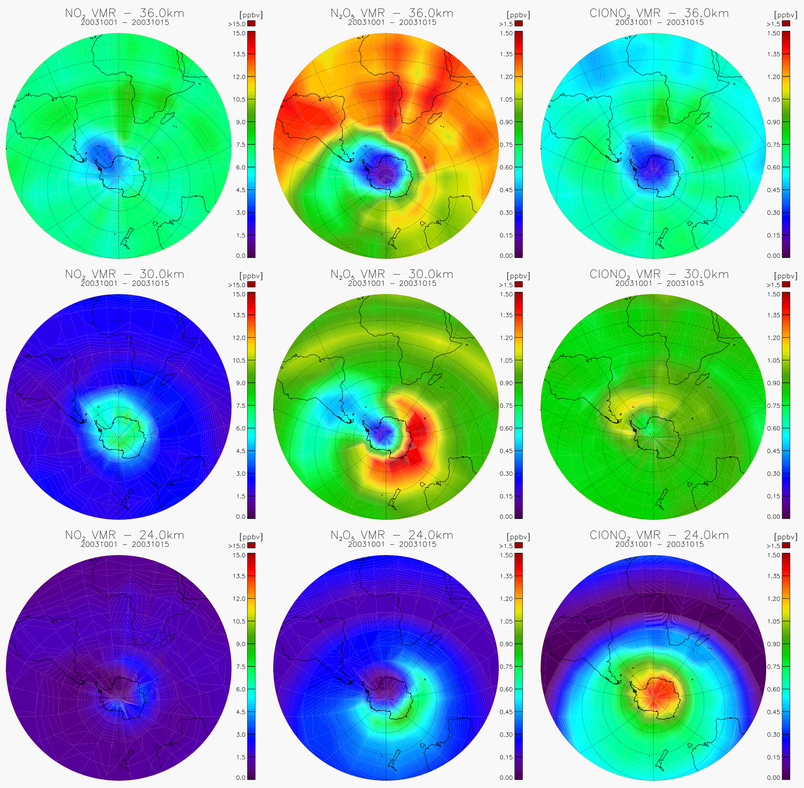

Figure 2: NO_2, N_2O_5, $ClONO_2$ mean maps (1^{st} – 15^{th} Oct 03)

- Figure 3 shows average maps of minor species VMRs calculated for March 2003 and July 2003 over the whole the globe at altitudes spanning from 12 km to 42 km.

N_2O_5 and $ClONO_2$ are shown in Orbital Coordinate (OC) in place of latitude since they have a strong diurnal cycle. The orbital coordinate follows the satellite orbits, starting at the North Pole at 0°, descending to the Equator at 90°, crossing the South Pole at 180°, and ascending through the Equator at 270° up to the North Pole again at 360°. Over the tropics, the first part of the orbit (OC < 180°) is acquired during day time, and the second during night time.

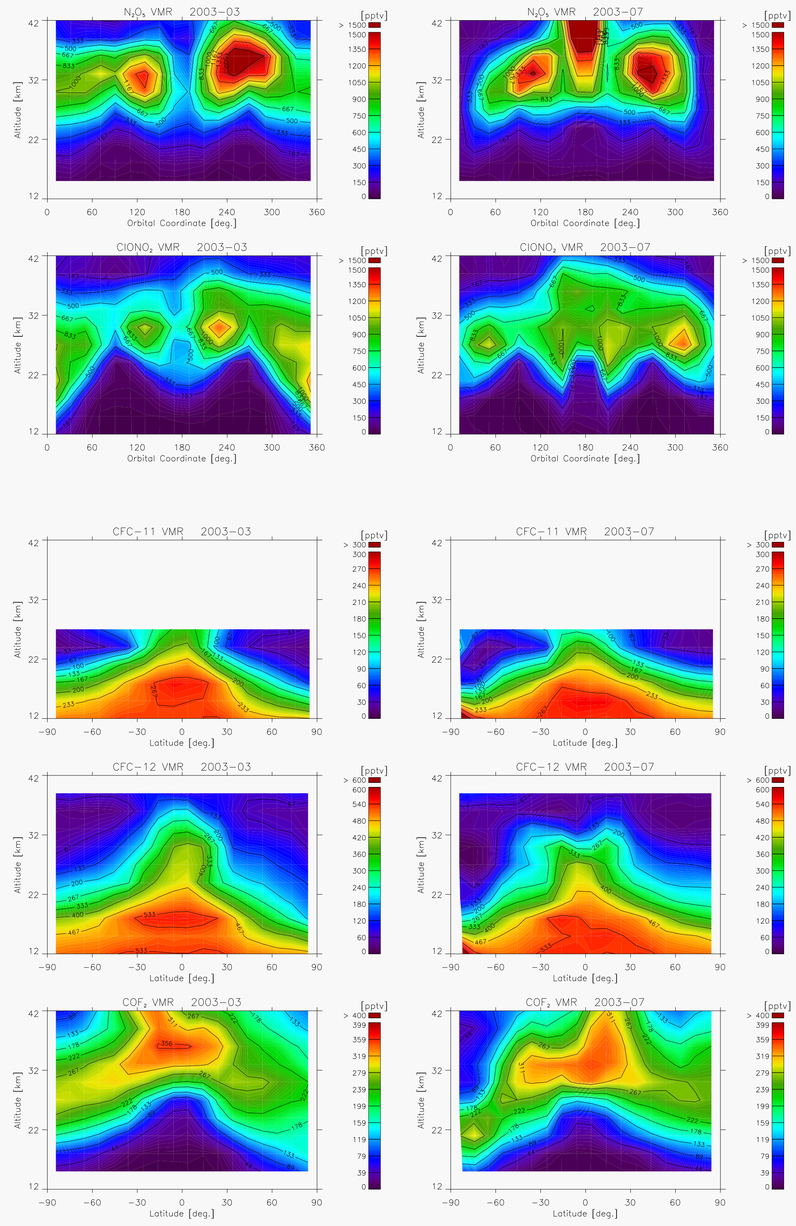

Figure 3: Monthly Mean Maps (March and July 2003)

FUTURE WORK

MIPAS2D was created as an advanced database of MIPAS GMTR-retrieved Level-2 products that can be exploited for the understanding of the evolution of the stratosphere during MIPAS lifetime. Next to ESA main target quantities, the database was extended to minor species with high signal to noise ratio. Further analyses of other atmospheric targets is undergoing exploiting the atmospheric fields stored in the DFCI-ISAC database and specific targets can be investigated on request.

References

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[3] `http://envisat.esa.int/services/beat`.

[4] M. Carlotti et al. Geo-fit approach to the analysis of satellite limb-scanning measurements. *Appl. Opt.*, 40:1872–1885, 2001.

[5] B.M. Dinelli et al. Multi-Target Retrieval (MTR): the simultaneous retrieval of pressure, temperature and volume mixing ratio from limb-scanning atmospheric measurements. *J. Quant. Spec. Radiat. Transfer*, 84:141–157, 2004.

[*] The DCFI-ISAC MIPAS2D database can be accessed via scp. For credentials, please send an e-mail to: mipas2d@safire.fci.unibo.it.

Web: `http://www.mbf.fci.unibo.it, http://www.isac.cnr.it/~rss/mipas2d.htm`