MULTI-TARGET RETRIEVAL OF THE VOLUME MIXING RATIO OF SF_6 FROM MIPAS SPECTRA

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Abstract

A retrieval approach for the simultaneous determination of the altitude distributions of pressure (*p*), temperature (T) and Volume Mixing Ratio (VMR) of atmospheric constituents from limb scanning measurements of the atmosphere has been developed and implemented in a computer code for the analysis of MIPAS-ENVISAT observations [*B.M.Dinelli, D.Alpaslan, M.Carlotti, L.Magnani, M.Ridolfi, 'Multi-Target Retrieval (MTR): the simultaneous retrieval of pressure, temperature and volume mixing ratio profiles from limb-scanning atmospheric measurements', Journal of Quantum Spectroscopy and Radiative Transfer, in press, (2003)*]. This analysis method, named Multi-Target Retrieval (MTR), has been used to retrieve the altitude distribution of the SF_6 VMR in the troposphere, from selected MIPAS orbits. The SF_6 profile was retrieved simultaneously with the *p*, T, water and ozone profiles analyzing selected spectral features of SF_6 jointly with the spectral intervals used by the ESA Level 2 processor for the sequential analysis of the MIPAS key species.

Introduction

Sulphur hexafluoride (SF_6), an anthropogenically produced compound, is rapidly increasing in the atmosphere, because of its very long lifetime (about 3200 years [Ravishankara et al., 1993]). It is an extremely stable gas and is used primarily as a dielectric gas in electrical transmission and distribution systems, specifically as an insulator for circuit breakers, switch gear, and other electrical equipment. SF_6 is also used in metal casting processes in magnesium foundries as well as in aluminium foundries.
Though the order of magnitude of SF_6 mixing ratio is approximately around few parts per trillion (ppt, 10^{-12} moles per mole in dry air) this species is one of the strongest known greenhouse gases due to its large "global warming potential" (GWP).

Experimental

The MTR approach has been used to retrieve the vertical distribution of the SF_6 VMR in the troposphere and in the low stratosphere (below 21 km) simultaneously tangent pressure, temperature, water vapour and ozone profiles. The main advantages of the MTR approach are:

- the uncertainty of the initial guess of the target quantities does not act as a source of systematic errors;
- in the iterative procedure the risk of a lack of convergence is reduced;
- the selection of spectral intervals to be used in the analysis is less critical than in the case of sequential retrievals because it is no longer necessary to minimize the interferences among target species;
- the information on pressure and temperature is gathered from the spectral features of all target species.

The retrievals have been performed analyzing the same narrow spectral intervals (microwindows) used by the ESA Level 2 processor for the sequential analysis of the MIPAS *p*, T, H_2O and O_3 profiles jointly with a microwindow (947-949 cm^{-1}) covering part of the intense ν_3 Q branch of the SF_6 molecule (Fig. 1).
For each scan the profiles of *p*, T, water vapour and ozone have been retrieved on a grid ranging from 68 km to the lowest cloud-free geometry.
The retrieval of SF_6 has been generally performed on a 6-km-spaced retrieval grid (from 21 km to the lowest cloud-free altitude); this grid has been changed only when the 6-km-geometry was not effected by clouds: in this particular case a different set of altitudes has been used (21, 12, 6 km). Though quite a "degraded" retrieval grid has been adopted for SF_6, its microwindow has been used below 33 km.
For each scan the initial-guess profiles used in the retrievals were obtained by climatological data only, without any combination with the profiles retrieved in the previous sequence.
MIPAS orbits 2081, 2910 and 7419 have been analysed. The orbits 2910 and 7419 have been used to investigate the increase of the SF_6 VMR in the troposphere; these orbits, that overlap exactly, have been recorded with a temporal delay of about 10.5 months.

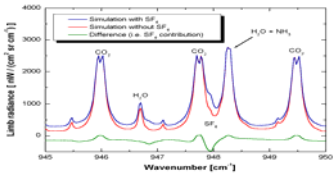

Fig. 1: Simulation of the spectral region where the ν_3 Q branch of the SF_6 lies (with and without the contribution of this gas).

Results

An overall picture of the quality of the retrievals is reported in Fig. 2, 3 and 4. Panels a) show the geo-location of the mid point of each limb-scanning sequence. The two-dimensional maps in the panels b) report the vertical distribution along the considered orbits of the SF_6 VMR (crosses mark the retrieval grids). Panels c) show the percentage ESD distributions and panels d) show the behaviour of the χ-test at convergence along the considered orbits. The results are reported as a function of the orbital coordinate, that is 0° and 360° at the North Pole (NP), 90° and 270° at the Equator (EQ) and 180° at the South Pole (SP).

Orbit 2081 (24th July 2002)

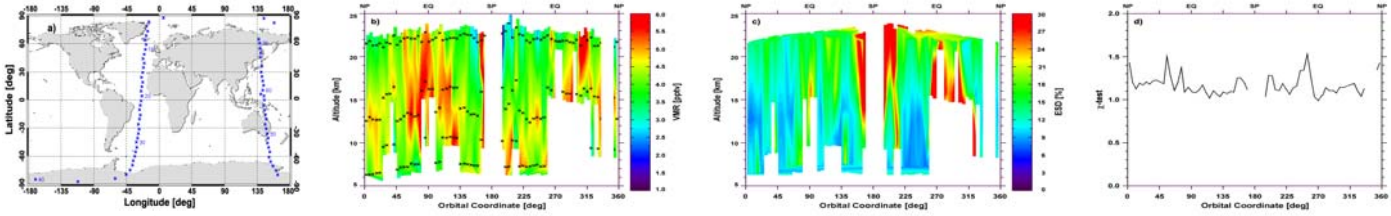

Fig. 2: Orbit 2081 (24th July 2002). a) Geo-location of the mid point of each limb-scanning sequence; b) Vertical distribution of the SF_6 VMR along the orbit; c) Vertical distribution of the percentage ESD along the orbit; d) behaviour of the χ-test at convergence

Orbit 2910 (19th September 2002)

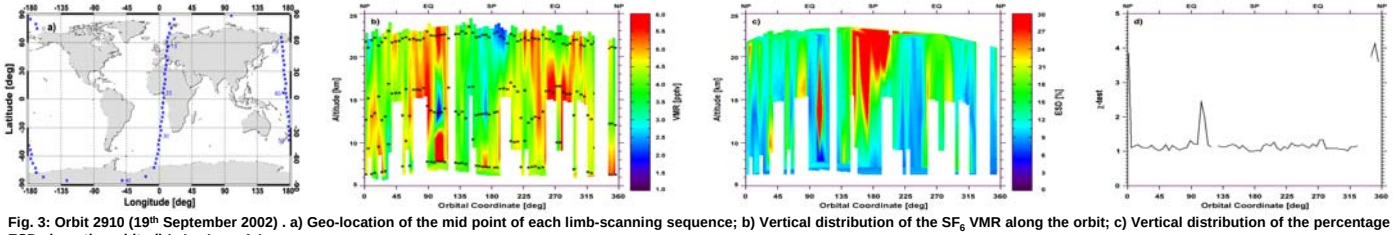

Fig. 3: Orbit 2910 (19th September 2002) . a) Geo-location of the mid point of each limb-scanning sequence; b) Vertical distribution of the SF_6 VMR along the orbit; c) Vertical distribution of the percentage ESD along the orbit; d) behaviour of the χ-test at convergence

Orbit 7419 (1st August 2003)

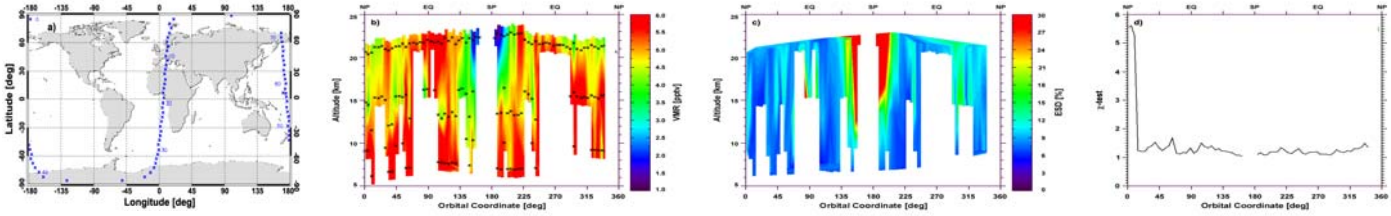

Fig. 4: Orbit 7419 (1st August 2003). a) Geo-location of the mid point of each limb-scanning sequence; b) Vertical distribution of the SF_6 VMR along the orbit; c) Vertical distribution of the percentage ESD along the orbit; d) behaviour of the χ-test at convergence

Conclusions

The VMR vertical distribution of SF_6, a very strong greenhouse gas, has been retrieved using the MTR approach. We have analysed three orbits recorded by MIPAS in different periods, so both temporal and latitudinal behaviour can be investigated. According to the results showed above, we can state that:

- the average values of the ESD calculated over all the retrieval grid points is nearly 15 % for the three analysed orbits;
- the latitude dependence of the SF_6 VMR follows the expected behaviour [Geller et al., 1997];
- 2002 measurements are in good agreement;
- the VMR map for the 2003 orbit shows a net increase with respect to the previous year, well beyond the error bars.