Retrieval of SF_6 from the MIPAS Satellite Instrument

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ABSTRACT

Preliminary work on retrieving sulphur hexafluoride (SF_6) from the MIPAS satellite instrument is presented here. Useful accuracy can be obtained over the altitude range 6-21 km, increasing to approximately 30 km when multiple scans are considered. Tropospheric values are in agreement with accepted trends.

INTRODUCTION

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) is one of the core experiments on ENVISAT, launched 1st March 2002[1]. MIPAS measures limb emission spectra over the altitude range 6-68 km. From these measurements, profiles of atmospheric temperature and composition can be retrieved.

The primary MIPAS operational products are temperature, O_3, H_2O, CH_4, N_2O, HNO_3 and NO_2. However, it is possible to retrieve many other trace gases from MIPAS data, in part due to its high spectral resolution.

Global measurements of SF_6 are important because of its strong greenhouse properties[2], many thousand times more powerful than CO_2. In addition, SF_6 is a long-lived species useful as a tracer[3]. As such, it can be used for understanding atmospheric dynamics and for testing the accuracies of transport models.

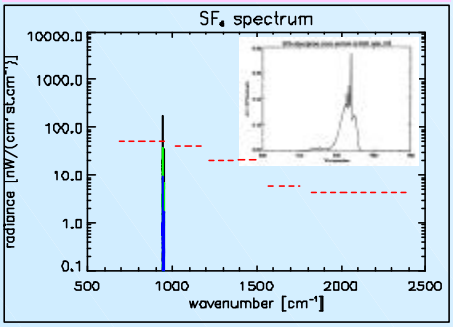

Figure 1: SF_6 band in context, with MIPAS NESR in red. Inset shows lab measurement of the strong ?$_3$ band[2] of SF_6.

MICROWINDOW SELECTION

In order to efficiently use the data from high resolution instruments, such as MIPAS, sections of spectrum, "microwindows" (MW), are selected to give the most information about the parameter to be retrieved. Microwindows are small spectral regions chosen to minimise both the random and systematic error components of the retrieval. The microwindow selection process models the propagation of random and systematic errors through the retrieval process, providing a full error analysis of the retrieval over the altitude range of interest.

ESTIMATED RETRIEVAL RANGE

The MW error analysis is shown in Figure 2. It indicates that we can retrieve SF_6 over the altitude range 6-21 km with some confidence. Above 30 km, the random errors become so high that the retrieval is no longer reliable. Indeed, visual inspection of co-added spectra shows no discernable spectral feature above 35 km.

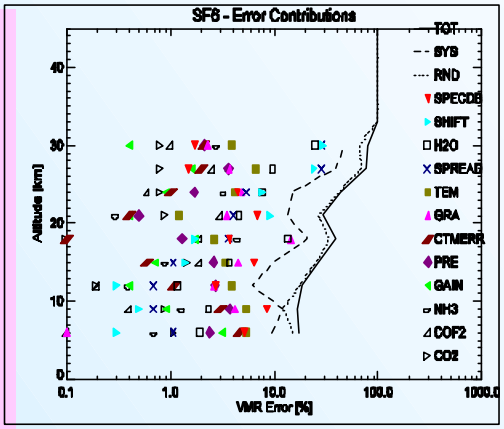

Figure 2: Error analysis for SF_6 microwindows. Water retrieval is the dominant systematic source above 20 km, spectroscopic uncertainty below.

RETRIEVAL RESULTS

The University of Oxford retrieval code, OPTIMO, uses an iterative fit with *a priori* constraints (optimal estimation) to invert MIPAS spectra. Retrieval diagnostics, such as the ?^{2} test along with cloud detection and compensation are also made use of.

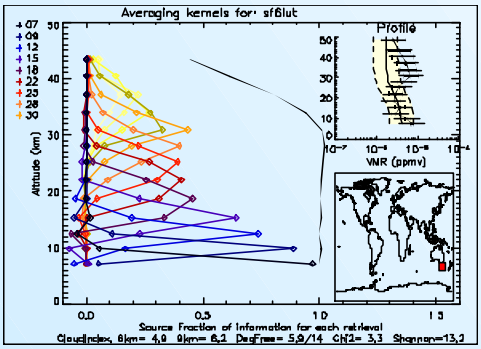

Figure 3: Averaging kernels (left) over the full retrieval range attempted. The resulting profile and geolocation are inset.

COADDITION OF PROFILES

As the retrieved profiles have a high random error due to the low signal strength, it was decided to investigate co-addition of retrieved profiles. Figure 4 shows the results of the retrieval, from 6-30 km and above to show how accuracy falls away. There is an awareness of the need to carefully propagate errors though this procedure and also account for the inclusion of *a priori* data in each profile.

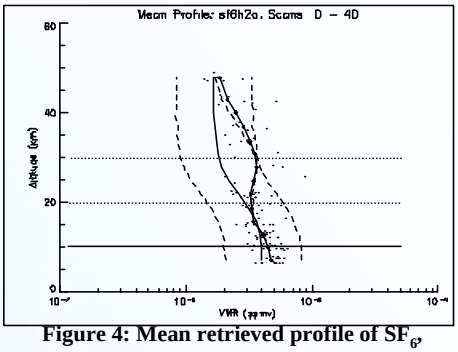

Figure 4: Mean retrieved profile of SF_6, with points from the constituent profiles over plotted. Lines indicate high, medium and no confidence.

CONFIRMING TRENDS

The concentration of sulphur hexafluoride has been rapidly increasing since the 1960s, due to anthropogenic emission. The mean retrieved tropospheric VMR of ~4 ppbv is in excellent agreement with published values and trends[4,5]. The uncertainty is currently estimated as less than +/- 1ppbv, and is expected to improve further.

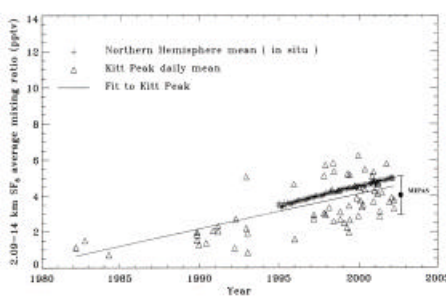

Figure 5: Recent published data[4] from ground-based and flask measurements, with the tropospheric MIPAS result over plotted.

CONCLUSIONS

- With the microwindows selected here, we can retrieve SF_6 with reasonable accuracy over the altitude range 6-21 km and up to 30 km.
- The random error is the biggest contribution to the total error at all altitudes for single profiles.
- Further work is to use statistical approaches to combine scans

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