



# Retrieval of Minor Atmospheric Constituents from MIPAS

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## ABSTRACT

Operationally only pressure, temperature and six significant trace gases are retrieved by ESA from MIPAS data. However, there are many interesting species that are also present in the spectra. We apply a variety of techniques to retrieve concentration information on these other species, such as sulphur hexafluoride and carbonyl sulphide, based on the optimal estimation approach.

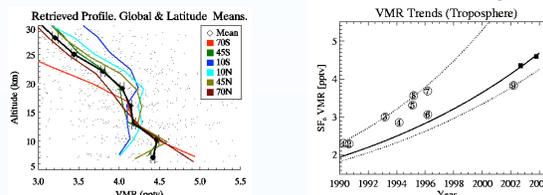
## INTRODUCTION

The Michelson Interferometer for Passive Atmospheric Sounding, MIPAS, was launched on Europe's environmental monitoring satellite, Envisat in March 2002. It is a high-resolution ( $0.025 \text{ cm}^{-1}$ ) Fourier transform spectrometer in a rearward-looking sun-synchronous polar orbit. In a single orbit it measures 70 profiles each of 17 levels that range from the upper troposphere to the lower mesosphere. Completing 14 orbits per day gives the instrument excellent coverage.

A large computational investment has been made to optimise microwindow selection, improving runtime and reducing systematic error. Improvements to our retrieval code, adding cloud detection and an optional sequential estimation pathway have also been made. Post-retrieval processing – applying statistical methods to reduce random errors and scatter in results such as  $\text{SF}_6$  – has shown promise.

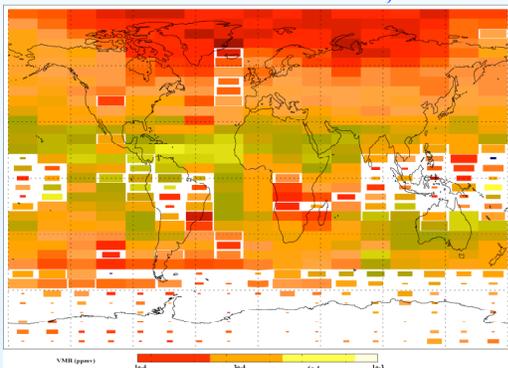
We present here the results from the retrieval of selected trace gases, and summarise the results of our feasibility studies on 11 significant species.

## SULPHUR HEXAFLUORIDE, $\text{SF}_6$



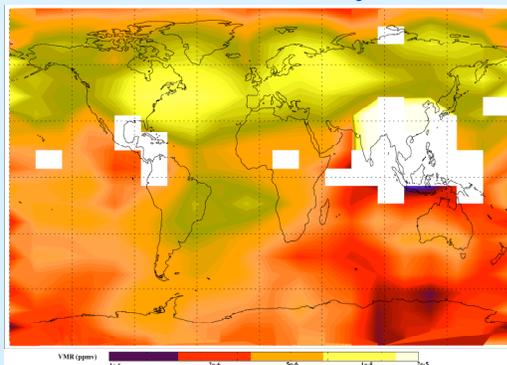
Results of co-addition of retrieved sulphur hexafluoride over various latitude bands (left). (right): Inferred global mean trend based on measurements 1 year apart; numbered circles are prior measurements, in the troposphere. Approximately 1600 profiles evenly covering the two hemispheres were used, after masking cloud-contaminated results.

## CARBONYL SULPHIDE, OCS



Global plot of OCS Volume Mixing Ratio (VMR) for January 2003 on a potential temperature surface of 500K (around 20km). Data is cloud-cleared and binned to an  $18 \times 36$  grid and local statistical outliers are removed before the mean is calculated for a grid square. 218 orbits were used, giving approximately 15000 profiles. Box size reflects certainty.

## AMMONIA, $\text{NH}_3$



A similar method was applied to this gridded ammonia plot for August 2003. The VMRs are at the 6km level only. The retrieval scheme made use of a sequential estimator (Kalman filter) of correlation length 20,000 km, which makes use of the state of the last successful retrieval to setup the next scan. This results in loss of some latitudinal structure. Orbits remain independent, however. Approximately 6,000 profiles used.

SPECIES	RANGE (km)	INFO (bits*)	Feasible retrieval in practice?
CFC-12	6 – 30	36.2	Yes. Retrieves latitudinal structure.
CFC-14	12 – 52	33.1	Yes, as F12. Very Noisy. Co-addition?
CINO <sub>2</sub>	18 – 39	25.0	Yes. Noisier retrieval than e.g. F12.
CFC-11	6 – 21	23.7	Yes. Consider co-addition.
HCFC-22	6 – 24	23.6	Limited. Only 1-2 degrees of freedom.
NH <sub>3</sub>	6 – 21	20.2	Limited. Only 1 level (6km).
HCN	12 – 18	19.2	Poor. Not investigated in detail.
COF <sub>2</sub>	15 – 33	18.7	Poor. Not investigated in detail.
SO <sub>2</sub>	6 – 24	17.2	Limited. Detect volcanism, perhaps?
OCS	9 – 12	15.2	Yes. Many interesting results already.
SF <sub>6</sub>	6 – 21	15.0	Yes. Trade time resolution : rnd. err.

This table shows probable top 11 non-operational species in terms of simulated retrieval accuracy, and expected altitude range. The green highlights show successful retrieval of a species. Yellow indicates restricted retrieval. The first column colours show our initial feasibility estimate. The final column summarises the results of our feasibility studies for actual retrievals, by various methods. \*Assuming that we start with an a priori uncertainty of 100% at 17 profile levels, we define information content as 1 bit for every factor 2 improvement at one level.

## CONCLUSIONS

- Work is concentrating on sulphur-containing gases, due to their involvement in aerosol formation. We have already seen interesting new results obtained from MIPAS spectra.
- We anticipate the good global coverage and continuity of data will make MIPAS useful for the determination of changes and trends in the quantity and distribution of a variety of species - both natural and anthropogenic.
- Microwindows now selected for many species:
  - $\text{N}_2\text{O}_5$ , HCN,  $\text{COF}_2$ , F14, ( $\text{COH}_2$  ... etc.) and preliminary attempts at retrieval performed – see below for the full list.
- Knowledge of climatology limiting factor in prediction of accuracy.
  - E.g.  $\text{NH}_3$  – Overestimated abundance and hence initial retrievability.

## FURTHER INFORMATION

The Oxford group performs a variety of retrievals and data health monitoring. For the latest information, please visit:  
<http://www.atm.ox.ac.uk/group/mipas/>

**CH<sub>4</sub> H<sub>2</sub>O N<sub>2</sub>O NO<sub>2</sub> O<sub>3</sub> PT SO<sub>2</sub> NH<sub>3</sub> OCS SF<sub>6</sub> HNO<sub>3</sub> COF<sub>2</sub> F12 CINO N<sub>2</sub>O<sub>5</sub> HCN F11 F14 F22 C<sub>2</sub>H<sub>6</sub> HOCl H<sub>2</sub>O<sub>2</sub> CCl<sub>4</sub> ClO CO**