New Species retrieved from Envisat/MIPAS

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INTRODUCTION

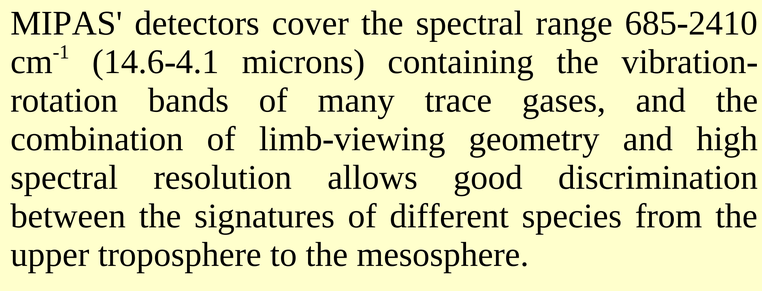
The Michelson Interferometer for Passive Atmospheric Soudning (MIPAS) is a limb-viewing infra-red fourier transform spectrometer which operated on the Envisat satellite from July 2002 until April 2012.

MIPAS' detectors cover the spectral range 685-2410 cm^{-1} (14.6-4.1 microns) containing the vibration-rotation bands of many trace gases, and the combination of limb-viewing geometry and high spectral resolution allows good discrimination between the signatures of different species from the upper troposphere to the mesosphere.

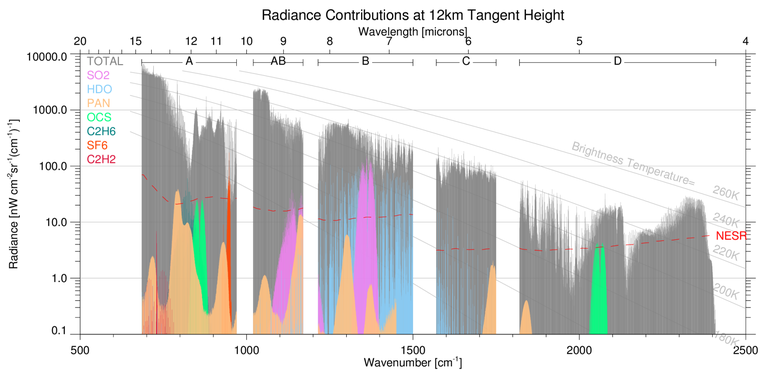
The original list of ESA L2 products retrieved from MIPAS consisted of profiles of Temperature, H2O, O3, HNO3, CH4, N2O and NO2. This was later extended to include ClONO2, N2O5, CFC-11 and CFC-12 and, more recently, CO, HCN, HCFC-22, CF4, CCl4 and COF2.

Here we present test results for potential new species to be added in the next reprocessing: C2H2, C2H6, OCS, PAN, SF6, SO2 and HDO.

INFRARED SPECTRUM



Above is a simulated MIPAS spectrum for a tangent height of 12km showing the spectral features associated with the atmosphere's main infrared emitting species in the 5 MIPAS bands. It is not essential to use a spectrally resolving instrument to retrieve most of these species, although doing so does improve accuracy. Below is a plot showing the spectral features of minor species examined here. High spectral resolution *is* essential to separate these from the major absorbers.



STANDARD RETRIEVAL

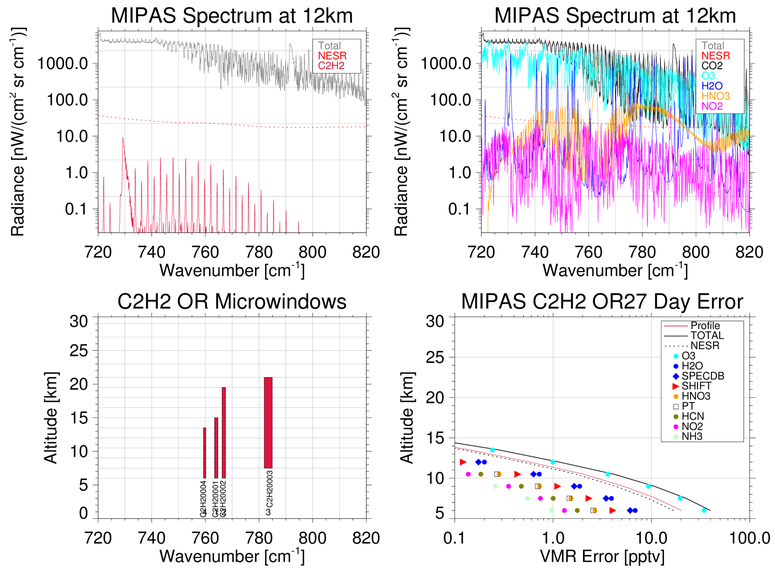
For the ESA processor it is desirable to find species which can be retrieved with essentially the same algorithm and code as the major species. This means

- An independent profile retrieved from every limb-scan (i.e. no averaging of spectra)
- Single target species retrieval (i.e. no joint retrievals with interfering species)
- Use of up to 5 microwindows of max 3cm-1 width
- Spectrally flat atmospheric continuum term fitted within each microwindow.

With future updates to the ESA software, particularly relaxing the first two requirements, it should be possible to retrieve additional species.

The following panels show results of a microwindow selection based on modelling instrument noise (NESR) as well as a variety of instrument and forward modelling errors through the 'standard retrieval', aiming to obtain the best accuracy, or minimum 'Total' error curve, shown in the lower right plots in each panel.

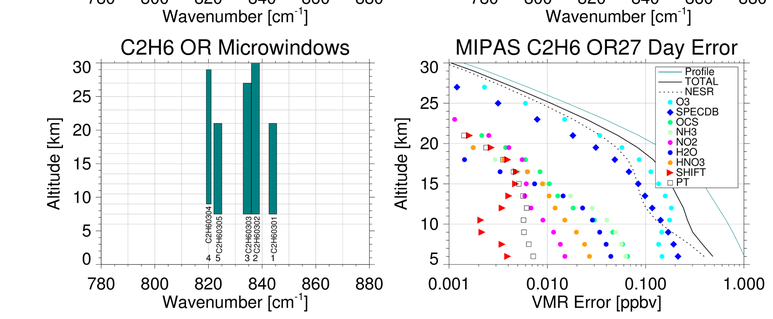
C2H2 (acetylene)



Top left: target molecule spectrum compared to total emission spectrum at 12km tangent altitude. Top right: local contributions from major interfering species. Bottom left: location of selected microwindows for retrieval. Bottom right: error analysis for single profile assuming mid-latitude day-time conditions.

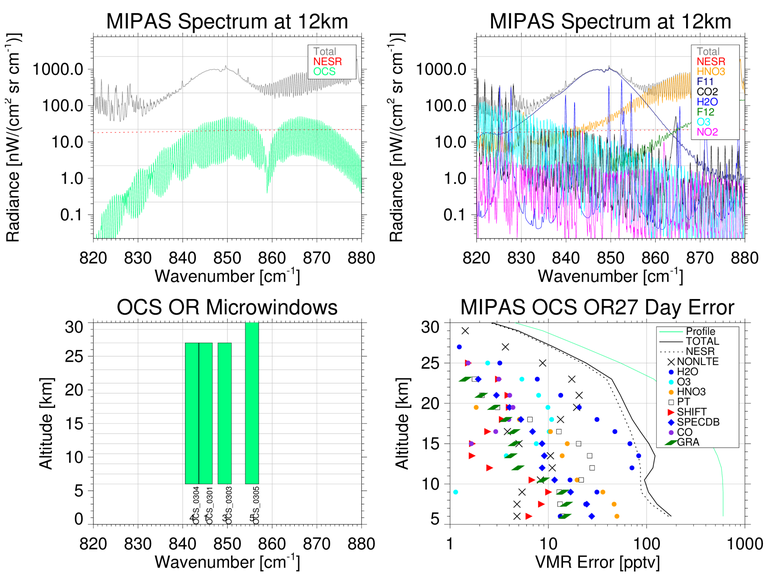
C2H2 has only a relatively weak emission feature between 800-860cm^{-1}. Even so, retrieval accuracy is limited by ozone interference rather than NESR. It is unlikely that this can be retrieved using the standard set-up.

C2H6 (ethane)



C2H6 has a spectral signature which exceeds the MIPAS noise in the 820-840 cm^{-1} region. A retrieval accuracy of around 0.1 ppbv (40% of the assumed profile) seems achievable, limited primarily by ozone interference and spectroscopic uncertainties (SPECDB).

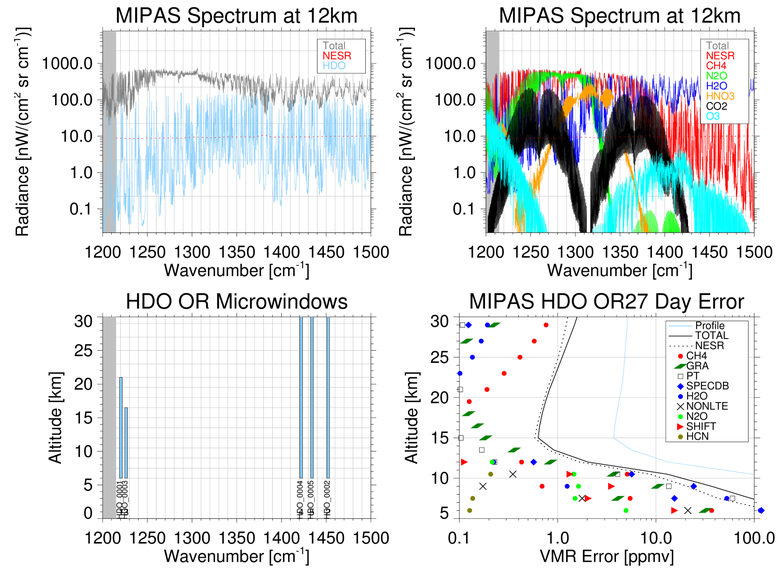
OCS (carbonyl suphide)



OCS has spectral features between 840-870 cm^{-1} and (not shown) 2040-2080 cm^{-1}. It should be possible to retrieve profiles to an accuracy of 100 pptv (25%) in the UTLS, limited by random noise.

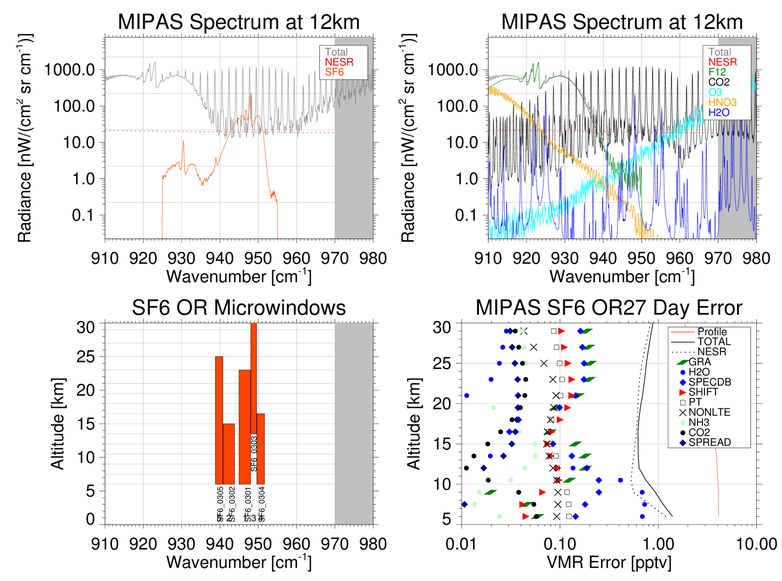
In these error analyses it is assumed that the *a priori* (random) uncertainty is 100%, indicated by the 'Profile' curves. Where the NESR error curve converges to this 100% value, essentially no information is available from the measurements.

HDO (deuterated water)



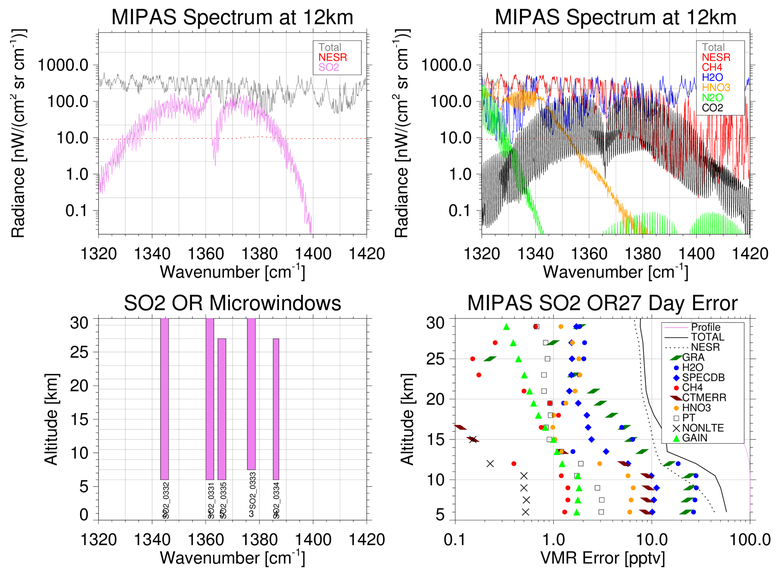
HDO has strong spectral features in the MIPAS B-band, distinct from the main isotopologue. Accuracies of around 10% in the UTLS seem achievable, limited by instrument noise (thus improved by spatial averaging).

SF6 (sulphur hexafluoride)



SF6 has a detectable signature between 940-950cm-1 coinciding with an almost transparent region of the spectrum (apart from CO2 lines). As a stable molecule it has an almost constant mixing ratio with altitude and seems to be retrievable with about 20% accuracy, limited by noise.

SO2 (sulphur dioxide)



SO2 error analyses were performed for a factor 10 enhancement in background concentration (e.g., post-volcanic conditions). This suggests a noise-limited accuracy of around 10 pptv is achievable, *cf* 50 pptv background concentration.

CONCLUSIONS

Based on these simulations it should be possible to obtain meaningful profiles of C2H6, OCS, SF6 and HDO using the standard ESA retrieval.

It may also be possible to retrieve C2H2, SO2 and PAN (results not shown), but only in enhanced conditions.