Retrievals of isotopic ratios of water vapour and methane from the MIPAS satellite instrument

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Introduction

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) is a high resolution limb sounder flying on the European Space Agency's Envisat satellite. MIPAS measures infrared atmospheric limb emission spectra from 685-2410cm^{-1} with a resolution of 0.025cm^{-1}, over an altitude range of 6-68km. After suitable ground processing, these spectra allow retrieval of concentration profiles of numerous atmospheric trace gases. The MIPAS spectra also contain enough information to distinguish minor isotopes of many of these gases. Measurements of the isotopic composition of atmospheric gases can provide valuable information on the origin of these gases and can also be useful for studying various atmospheric processes including dynamics, transport and stratospheric-topospheric exchange. Here we examine isotopes of water vapour and methane. Figure 1 outlines the main processes that cause atmospheric isotope abundances to differ from isotopic abundances at the surface.

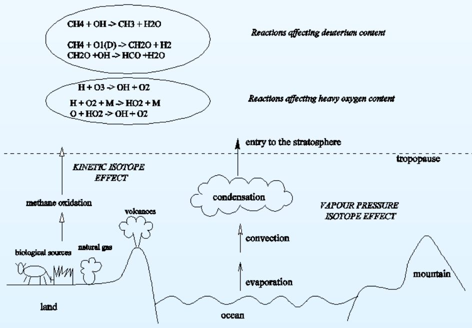

Figure 1: processes leading to isotope fractionation

Microwindow selection

With a high spectral resolution instrument like MIPAS, it is usual to select narrow spectral intervals (microwindows) containing the best information on the target parameters. Here we have used a microwindow selection technique developed at the University of Oxford (*Dudhia et al, 2002*). The microwindow selection process selects spectral regions by simulating a full profile retrieval, including the propagation of the random noise and the systematic error components (such as interference from non-target species and instrumental effects) through the retrieval

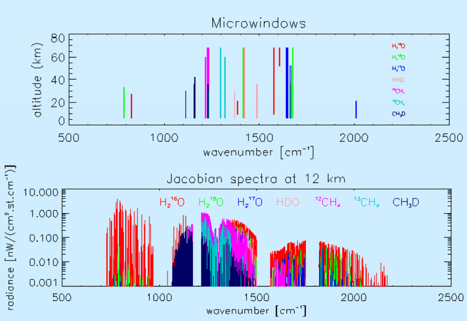

Figure 2: Positions of microwindows in the spectral and altitude domain

Water vapour isotope retrievals

Retrievals of H_2O, HDO and $H_2^{18}O$ have been performed for MIPAS orbit 2081, which occured on 24th July 2002. Isotopic variations are usually expressed using δ-notation, in units of per mil:

$\delta D = \{([HDO]/(2[H_2O]) - R_0)/R_0\} * 1000$

$\delta^{18}O = \{([H_2^{18}O]/[H_2O] - R_0)/R_0\} * 1000$

where R_0 is a standard isotope ratio (eg from SMOW – see *Craig, 1961*)

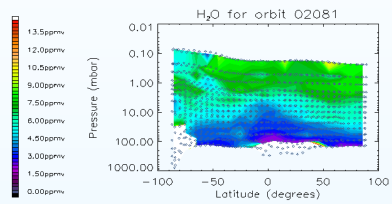

Figure 3: Latitudinal variation of retrieved H_2O for orbit 2081, with positions of tangent points marked as diamonds. The error on a single profile is of the order of 10%

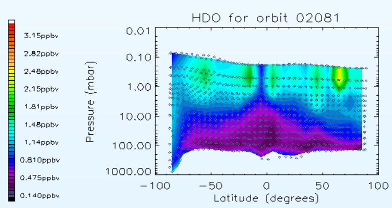

Figure 4: Latitudinal variation of HDO for orbit 2081. The error on a single profile is of the order of 20-30%

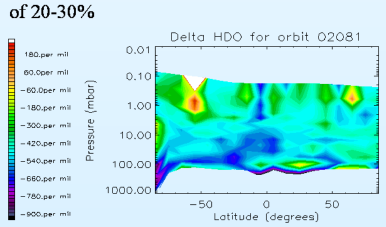

Figure 5: Latitudinal variation of δD in HDO for orbit 2081

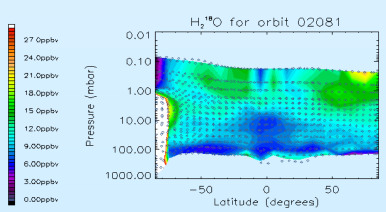

Figure 6: Latitudnal variation of $H_2^{18}O$ for orbit 2081. The error on a single profile is of the order of 20-30%

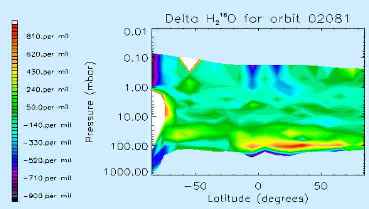

Figure 7: Latitudinal variation of $\delta^{18}O$ in $H_2^{18}O$ for orbit 2081

Methane isotope retrievals

Retrievals of $^{13}CH_4$ and CH_3D have not yet been completed for all of orbit 2081, but the results obtained so far are shown below.

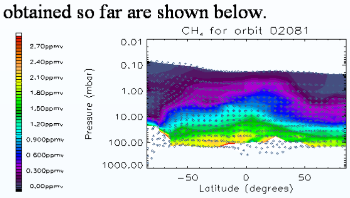

Figure 8: Retrieved CH_4 for orbit 2081. Positions of tangent points are marked as diamonds. The error on a single profile is of the order of 10%

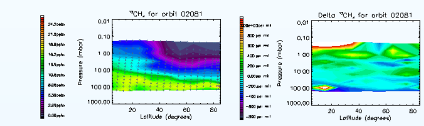

Figure 9: Retrieved $^{13}CH_4$ (left) and delta values (right). The error on a single profile is of the order of 30%.

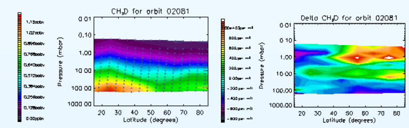

Figure 10: Retrieved CH_3D (left) and corresponding delta values (right). The error on a single profile is of the order of 30% up to 30km, and much greater above that

Summary

The retrievals of HDO for orbit 2081 agree at least qualitatively with what would be expected from model calculations (e.g. *Ridal 2002*). The retrieval error for the minor isotopes is limited by the random error, so the total error could be reduced by averaging profiles. Initial results look promising. Retrieval results for $H_2^{18}O$ show more enrichment than would be expected. This will require further investigation.

Error estimates from the microwindow selection inidicate that there is enough information in the MIPAS spectra to perform successful retrievals. However, results are quite different from what would have been expected from other measurements (e.g. *Rice et al., 2003, Rinsland et.al, 1991*). Again, this will require further investigation.

References

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