MIPAS Products Retrieved at Oxford

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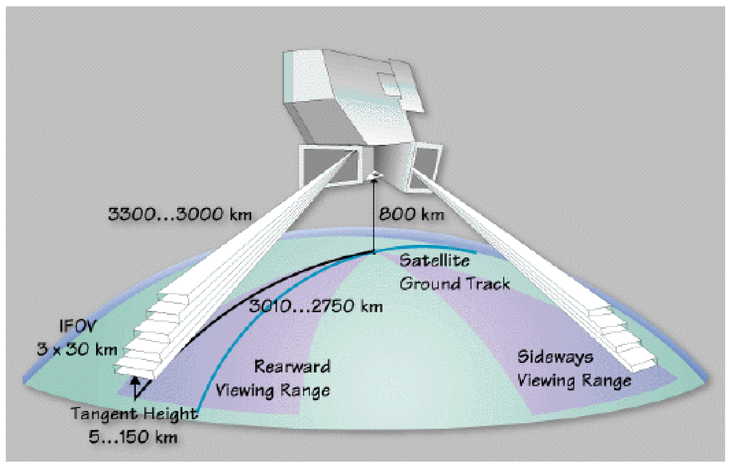
INTRODUCTION

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

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

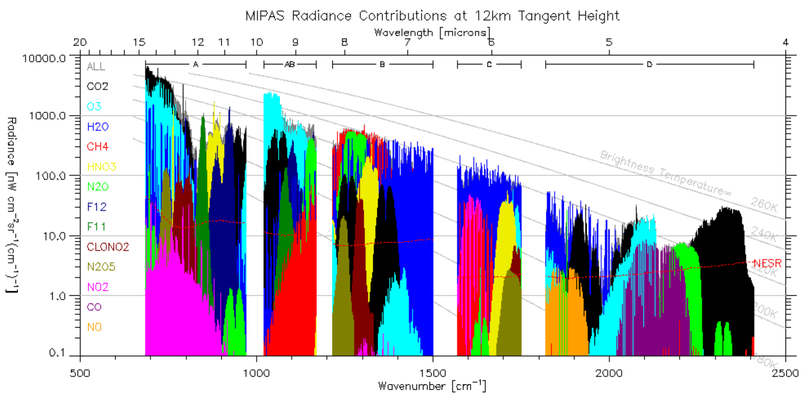
Oxford is one of several groups which use the same MIPAS spectra to generate profiles of temperature and concentration of different species. Here an overview is presented of the Oxford products.

THE MIPAS INSTRUMENT



In normal operation MIPAS viewed rearward along the orbit track giving pole-to-pole coverage and approximately 14 orbits per day. It scanned in elevation to acquire a set of limb emission spectra from tangent altitudes from approximately 70km (mesosphere) down to 6km (troposphere) every few hundred km along the orbit track.

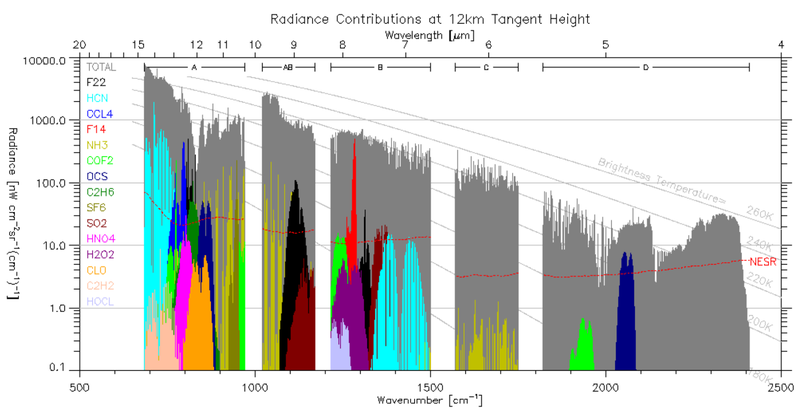
THE INFRARED SPECTRUM



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 minor species. High spectral resolution *is* essential in order to discriminate emission features of these molecules from the stronger emitters.

The red dashed line shows the Noise-Equivalent Spectral Radiance, i.e., the noise on a single measured spectrum. S/N can be improved by averaging over many lines or (at the expense of spatial resolution) spectra.

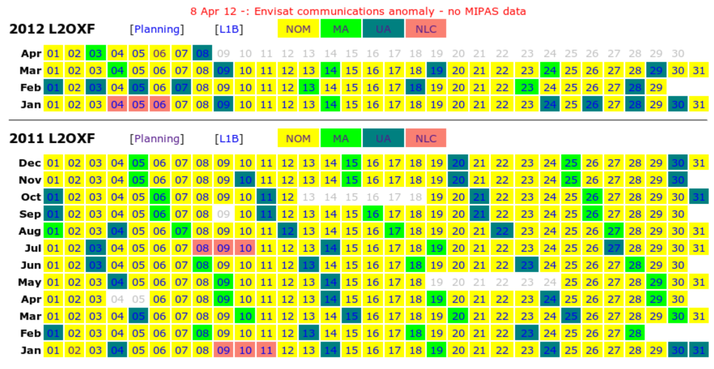


OXFORD PROCESSING

MIPAS spectra from ESA ('L1B Data') have been processed at Oxford to generate profiles of Temperature and composition ('L2 Data') at approximately 500km spacing along the orbit track, 14 orbits per day. The molecules retrieved in data v1.4 are listed in the table below.

Atmospheric Species Retrieved in v1.4 of the Oxford MIPAS L2 data		
Major Species	Anthropogenic Species	Minor Species
H2O	CFC-11	C2H6
O3	CFC-12	CCl4
HNO3	CF4	COF2
CH4	SF6	HCN
N2O	HCFC-22	HOCl
NO2		OCS
N2O5		
ClONO2		
CO		

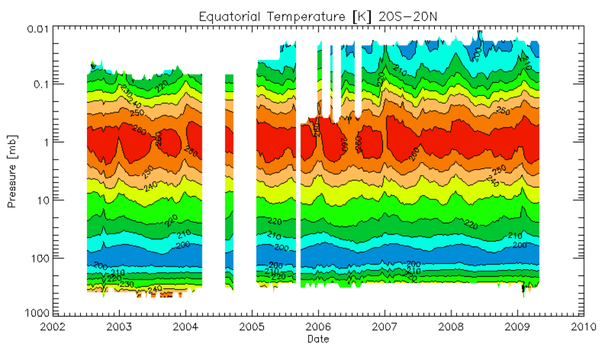
Some new molecules being considered for the next version of processing are: C2H2, CH3Cl, ClO, COCl2, CFC-113, CFC-114, H2CO, H2O2, HCOOH, SO2, HDO, CH3D and isotopomers of O3.



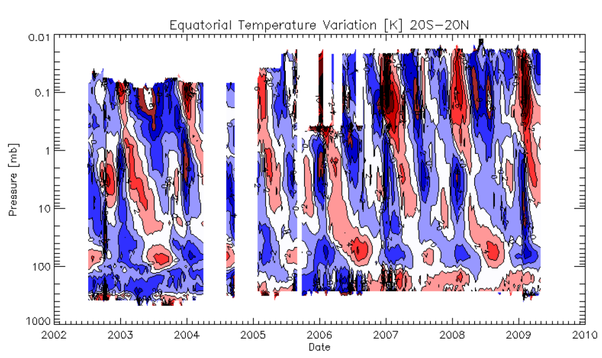
Part of the Oxford L2 Data Calendar web-page showing days for which MIPAS data are available, with the different colours indicating different operating modes of the instrument.

TIME SERIES

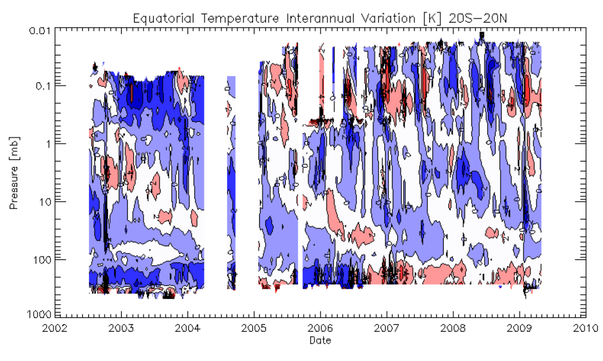
MIPAS data extend from July 2002 to April 2004, almost 10 years. Such a dataset can provide useful information on interannual variability and longer-term trends. However, in 2004, the spectral resolution was changed from 0.025cm^{-1} to 0.0625cm^{-1}, and various other changes to the instrument operation have occurred, so some caution is needed when interpreting results.



Time series of equatorial temperature 2002-2009. Note the interruption in operation for much of 2004 and the variable upper altitude limit.



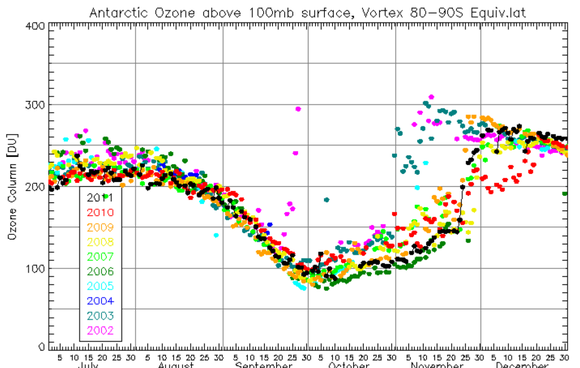
Temperature time series as above but with the mean vertical profile subtracted, revealing the annual temperature cycle in the lower stratosphere (100mb, 15km) with a semi-annual cycle in the upper stratosphere (10-1 mb, 35-50km)



The same time series but now with the mean annual cycle removed, showing the slow downward phase propagation associated with the Quasi-Biennal Oscillation (QBO).

OZONE HOLE

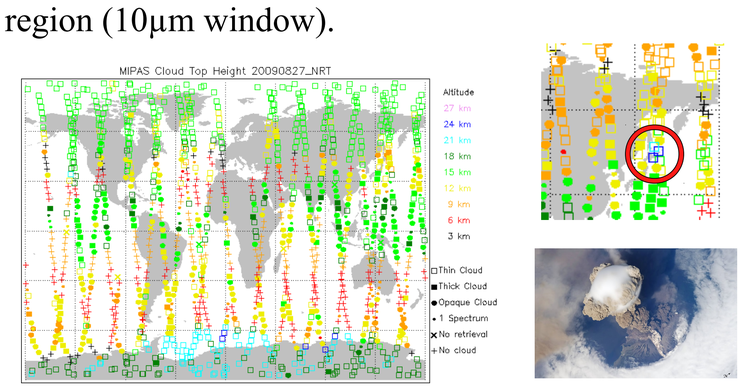
MIPAS has pole-to-pole coverage and senses thermal emission rather than scattered sunlight, so works equally well in day or night. These characteristics make MIPAS an ideal instrument for monitoring the evolution of the polar vortex through the winter and into spring



Antarctic Ozone above 100mb surface 2002-2011 as retrieved from MIPAS. The 'ozone hole' typically develops throughout August and September, dispersing some time during October as the polar vortex breaks down (2002 - shown in pink - was an unusual year in that the normally-stable polar vortex split in two allowing the ozone-rich air from lower latitudes to enter the polar region earlier than usual).

CLOUD RETRIEVALS

Temperature and composition are retrieved from the molecular line components of the observed spectra, but the 'continuum' between the lines can also be used to deduce cloud and aerosol properties. Part of the Oxford processing suite consists of a simple model used to determine cloud top height, temperature and extinction using regions around the CO2 lines in the 900-1000cm^{-1} region (10μm window).



The main plot above shows the results for 27 Aug 2009. Apart from the expected Polar Stratospheric Clouds at high altitude in the Antarctic, this also shows a uniform thin cloud coverage at around 15km altitude throughout the Arctic. Working backwards this can be traced to the eruption of the Sarychev volcano in the Kuril islands (just north of Japan) in mid-June 2009. The upper right plot shows a detail of the retrievals for 18 June where the circled area shows cloud detected at 24km above the volcano. The photograph, taken from the ISS, shows an earlier eruption on 12 June.

OTHER SOURCES OF MIPAS DATA

Other groups also retrieve L2 products from MIPAS spectra using different algorithms. The Oxford scheme is actually used as a testbed for new products to be incorporated into the ESA processor, using the same microwindows (spectral subsets) and absorption coefficient look-up tables.

Within NCEO, groups at the University of Leicester and RAL also have their own retrieval schemes.

Retrievals are also performed by groups in Italy (IFAC, U.Bologna), Germany (IMK, FZJ) and Spain (IAA).

For further information see

www.atm.ox.ac.uk/group/mipas

or Google 'MIPAS' and 'Oxford'