Analysis of MIPAS data at Oxford

Anu Dudhia

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Atmospheric, Oceanic & Planetary Physics
Dept of Physics, University of Oxford

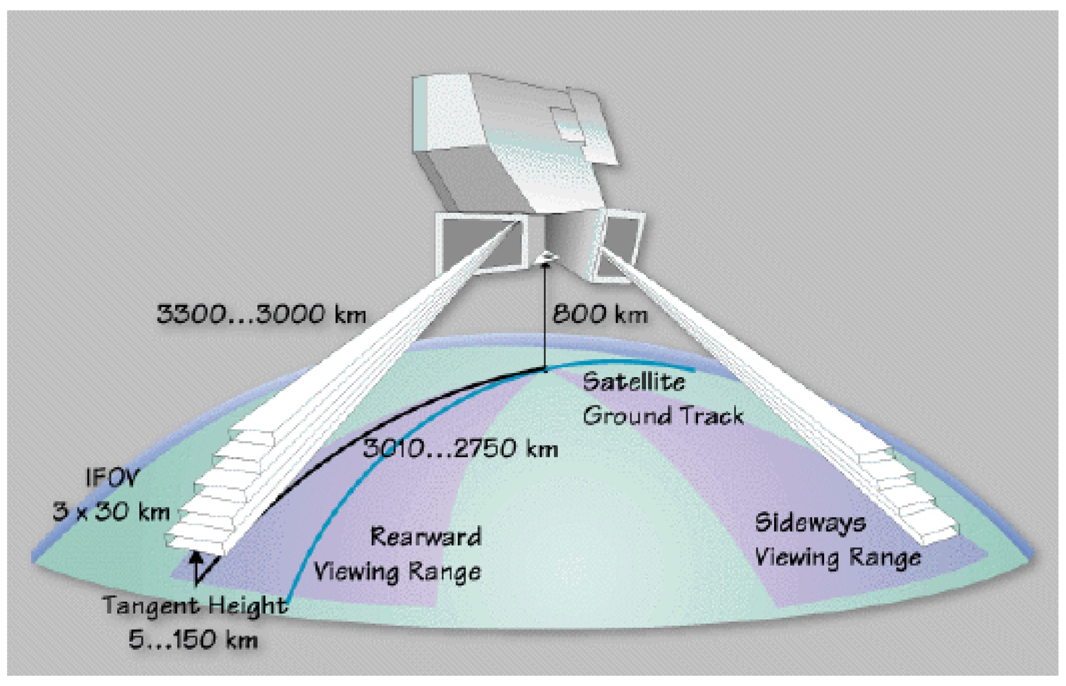
INTRODUCTION

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) is a limb-viewing fourier transform spectrometer on the ESA Envisat satellite launched in 2002.

MIPAS makes global measurements of infrared spectra in the range 4-15µm at tangent heights from the mesosphere down to the mid-troposphere. From these spectra, vertical profiles of atmospheric temperature and composition can be retrieved.

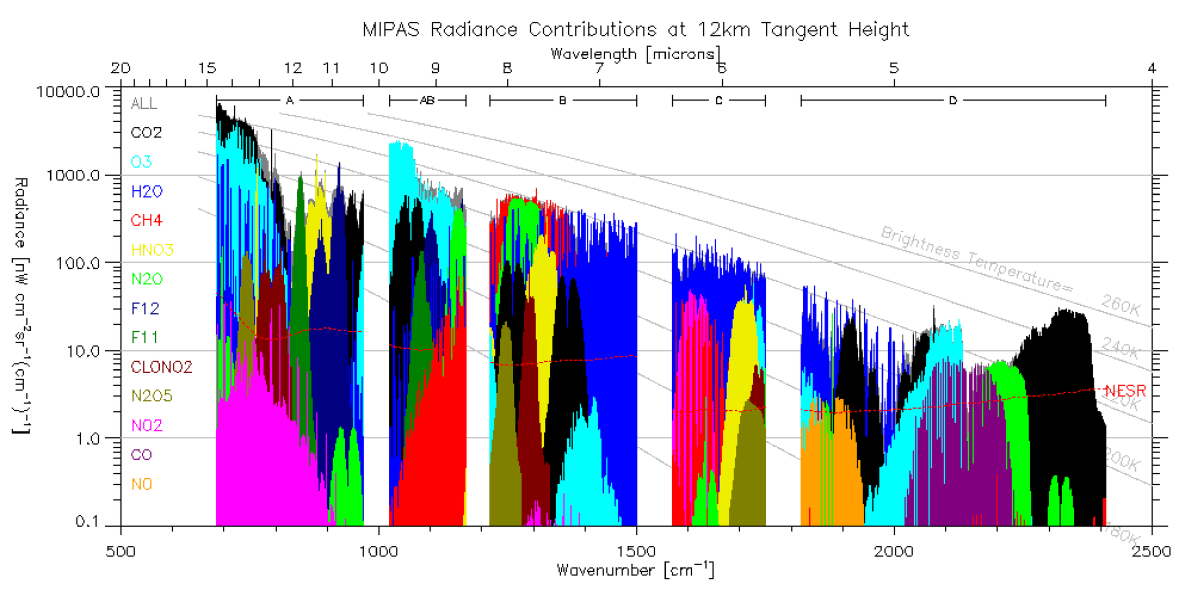
ESA's operational retrieval has so far only processed a limited amount of data. However, Oxford has its own retrieval scheme which has been used to process the full dataset and continues to process data in near real time.

THE MIPAS INSTRUMENT



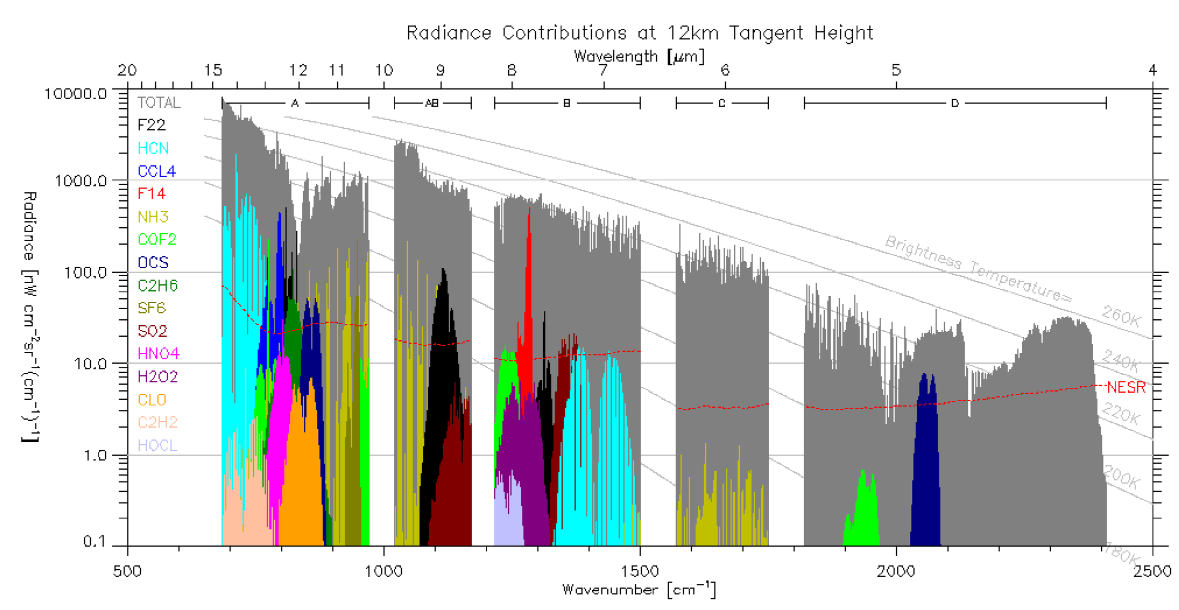
In normal operation MIPAS views rearward along the orbit track giving pole-to-pole coverage and approximately 14 orbits per day. It scans in elevation to acquire a set of limb emission spectra from tangent altitudes from approximately 70km (mesosphere) down to 6km (troposphere) every few hundred km along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

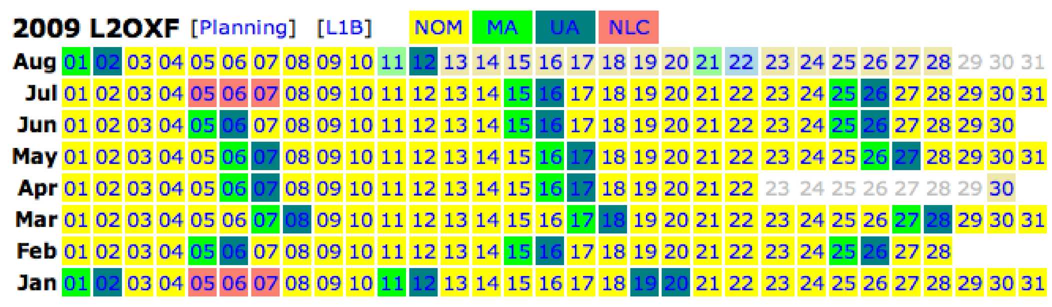


OXFORD PROCESSING

MIPAS spectra from ESA ('L1B Data') are routinely downloaded and processed at Oxford to generate profiles of Temperature, H_2O, O_3, HNO_3, CH_4, N_2O and NO_2. The scheme is similar to the ESA operational retrievals for these products but uses an optimal estimation algorithm rather than a regularised least squares fit. In addition, CFC-11, CFC-12, N_2O_5 and $ClONO_2$ are retrieved. These are likely to be included in the next version of the ESA L2 processing.

There are actually two versions of L1B data: the 'Near Real Time' (NRT) data which are available ~1 hour after acquisition, and 'Off-Line' (OFL) or 'Consolidated' data which appear around 1 week later. The OFL data are less fragmented and, in theory, better calibrated than NRT data but in practice the difference in quality is not significant.

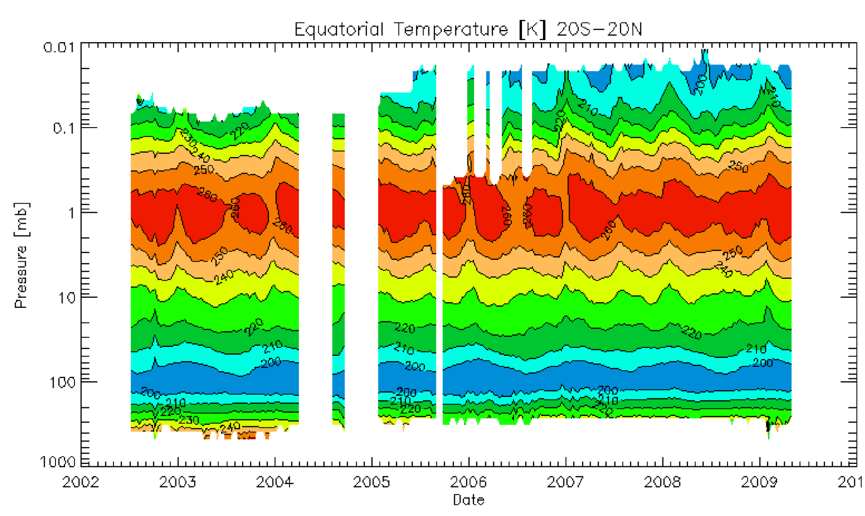
Both sets of data are processed at Oxford, the NRT products being available ~1 day after acquisition and ~2-3 weeks for OFL data.



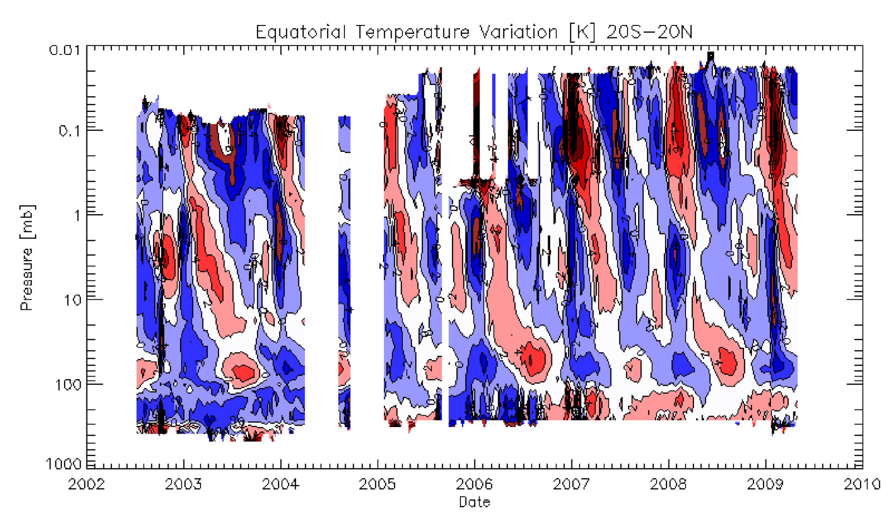
Snapshot of the Oxford L2 Data Calendar web-page, showing days for which data have been processed. Different colours refer to different operating modes of the MIPAS instrument (i.e. scan patterns) with the lighter colours indicating days for which only NRT data is currently available. Clicking on each date brings up plots showing maps of profile locations for that day.

TIME SERIES

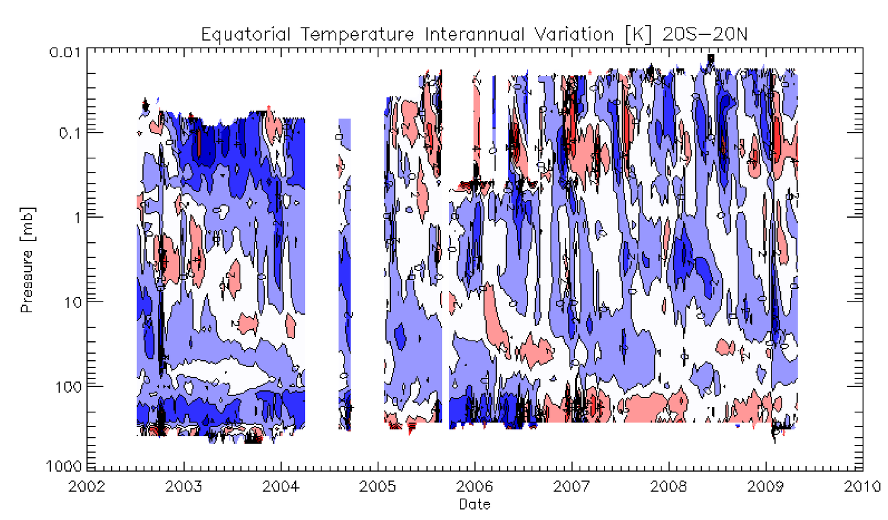
MIPAS data start in July 2002 and now extend for more than seven years. Such a dataset can provide useful information on interannual variability and possibly long-term trends. However, the spectral resolution was changed from 0.025cm^{-1} to 0.0625cm^{-1} during 2004, and various other changes to the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



Left: Time series of equatorial temperature as retrieved from MIPAS 2002-2009. Note the interruption in operation for much of 2004 and the limited altitude range during part of 2005-2006.



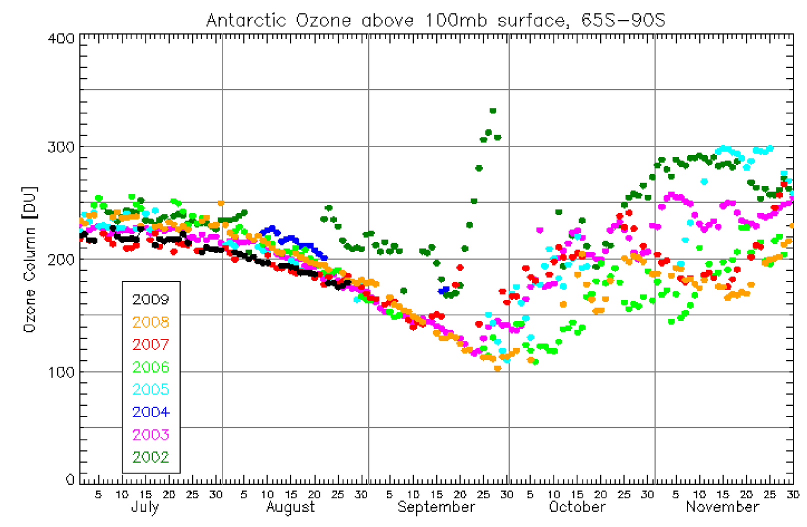
Right: Temperature time series as above but with the mean vertical profile subtracted. This reveals the annual temperature cycle in the lower stratosphere (~100mb, 15km) with a semi-annual cycle in the upper stratosphere (above the 10mb surface, ~35km)..



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

OZONE HOLE

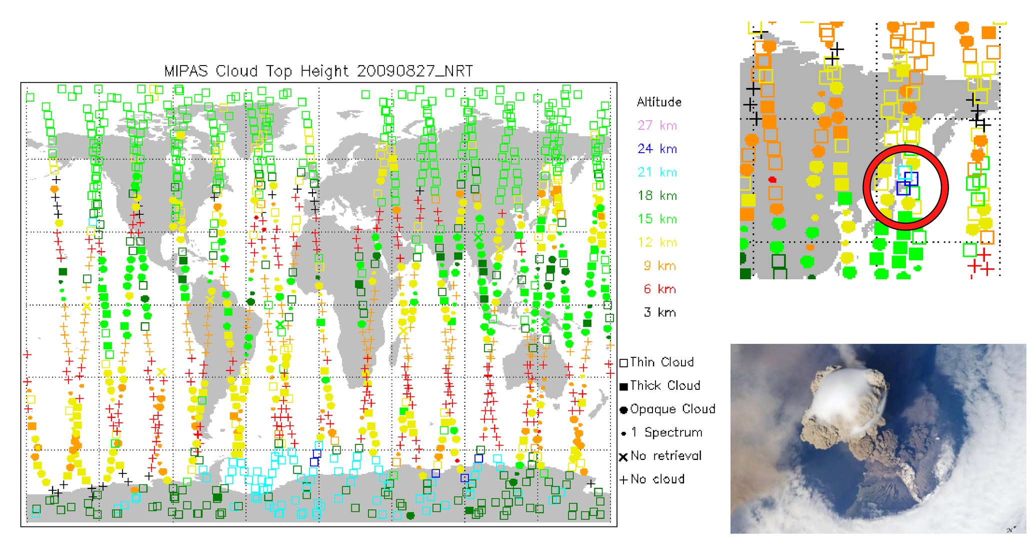
MIPAS has pole-to-pole coverage and senses thermal emission rather than scattered sunlight, so works equally well in day or night. These characteristics make MIPAS an ideal instrument for monitoring the evolution of polar ozone.



Current state of Antarctic Ozone as retrieved from MIPAS data (2009 shown in black) compared with previous years. The 'ozone hole' typically develops throughout August and September, dispersing some time during October as the polar vortex breaks down (2002 - shown in dark green - 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

A recent addition to the processing suite has been the retrieval of cloud top height, temperature and extinction by observing the 'continuum' emission between 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

Oxford currently has the most complete time series of MIPAS data. ESA's 'official' L2 dataset currently only extends up to March 2004 but they should process the subsequent data within the next few months.

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'