High Cloud Climatology from MIPAS-ENVISAT

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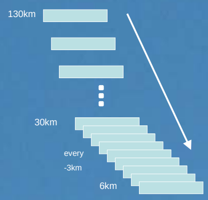
Clouds are a source of major uncertainty in climate models – it is thus important to accurately model clouds in order to determine their properties. In this work, three cloud parameters (cloud top height, cloud top temperature and cloud extinction coefficient) are used to model the radiance measured within the MIPAS field-of-view (FOV) as they represent the most obvious physical, thermodynamic and optical properties, respectively, of a cloud. Finally this model is implemented in an optimal-estimations-type retrieval of cloud top height, cloud top temperature and cloud extinction coefficient from a year's worth of MIPAS spectra.

Instrument Details and Cloud Detection

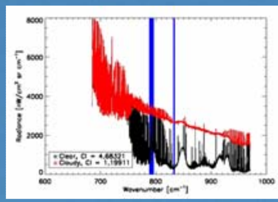
The Michelson Interferometer for Passive Atmospheric Sounding is an infrared limb-viewing Fourier Transform Spectrometer onboard ESA's ENVISAT satellite, launched in March 2002.

- 685 – 2410 cm^{-1}, at 0.0625 cm^{-1} resolution
- 6 – 68 km regular atmospheric coverage



Cloud detection by 'Colour Index' (CI) method, which uses two microwindows having different sensitivities to cloud presence by taking ratio of their radiances: $CI = L_{insensitive} / L_{sensitive}$

and thresholds so that CI < 1.8 indicates cloud.

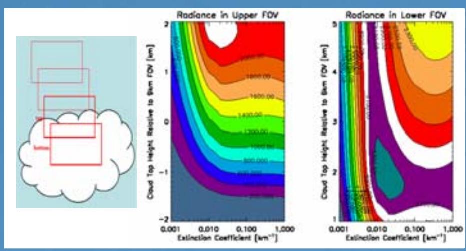


Macrophysical Cloud Parameter Model and Retrieval

Forward model assumes that:

- a cloud in the MIPAS FOV is horizontally homogeneous – that is, has a constant cloud top height across the FOV and can be characterized by a single extinction coefficient.
- the temperature structure within the cloud can be determined by the wet adiabatic lapse rate estimated downwards from cloud top temperature.

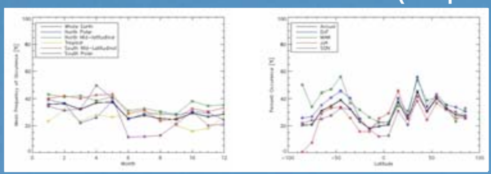
The forward model calculates the non-scattering radiance within the first MIPAS FOV encountering the cloud top, as well as that immediately below.



Retrieval uses radiances at 960 cm^{-1} in these two FOVs, as well as information derived from cloud effective fraction within the FOV and CIRA temperatures, to estimate cloud top height CTH, temperature CTT and logarithm of the extinction coefficient $\log(k_{ext})$ in a sequential optimal estimations scheme, iterating to find forward model parameters which minimize the cost function.

Application to 2003 MIPAS Data

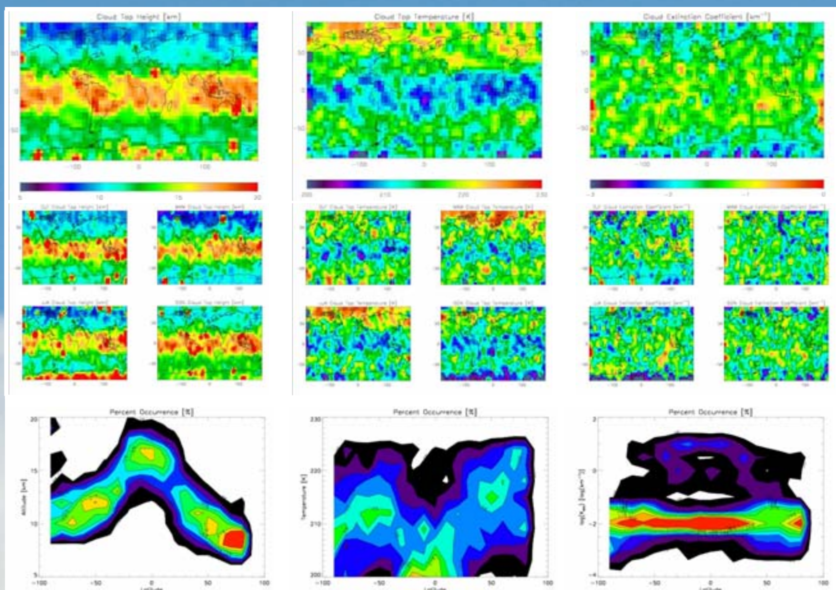
The retrieval scheme has been run on 2003 (sampled one day out of every ten) MIPAS spectra detected as cloudy by the CI method.



The frequency of occurrence of cloud occurring at some altitude globally as determined by the CI method – and hence upon which the retrieval scheme has been run – as a function of time for zonally-averaged data (left panel), along with the probability that cloud will occur at some point in the atmosphere as a function of latitude for the year as a whole and for different seasons (right panel).

The retrieved values of CTH, CTT and $\log(k_{ext})$ have been averaged in 5° by 5° latitude-longitude bins for the full year-long period of study. The resulting maps of high cloud CTH, CTT and extinction (top/middle panels for annual/seasonal means) exhibit some reassuring behaviour, namely:

- 'Hot spot' of high cloud over Indonesian toga core;
- Occurrence of high cloud over mountainous regions such as the Southern Andes and Rockies;
- Increased high cloud over Amazon Basin and the Congo;
- Increasing cloud top height towards the tropics;
- Retrieved CTT is nearly fully correlated with CTH.
- Retrieved $\log(k_{ext})$ is more or less constant over the globe – probably a result of picking the highest cloud only in the MIPAS scan to analyze, or of averaging.



Bottom panels show the probabilities as a function of latitude that, if cloud exists, that it does so at a certain height, temperature and extinction. An obvious bifurcation in extinction is visible – and is attributed to the detection of two predominantly different cloud types: thin cirrus and thick cloud occurring at similar altitudes.

This preliminary study confirms that cloud top height, top temperature and extinction coefficient can be successfully retrieved by modelling clouds quite simply and using a sequential optimal estimations-type retrieval whereby an estimate for cloud effective fraction initiates the retrieval close to the correct cost minimum. This retrieval method has been successfully applied to MIPAS's 2003 data to produce global maps of cloud top height, top temperature and extinction coefficient which compare well with existing cloud climatologies.

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