HiRDLS: Clouds

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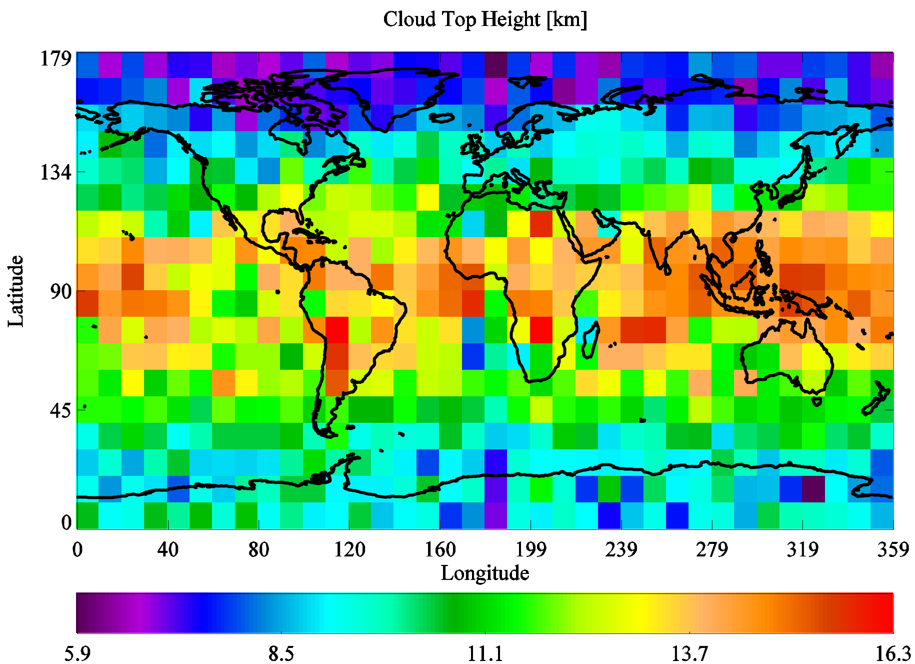
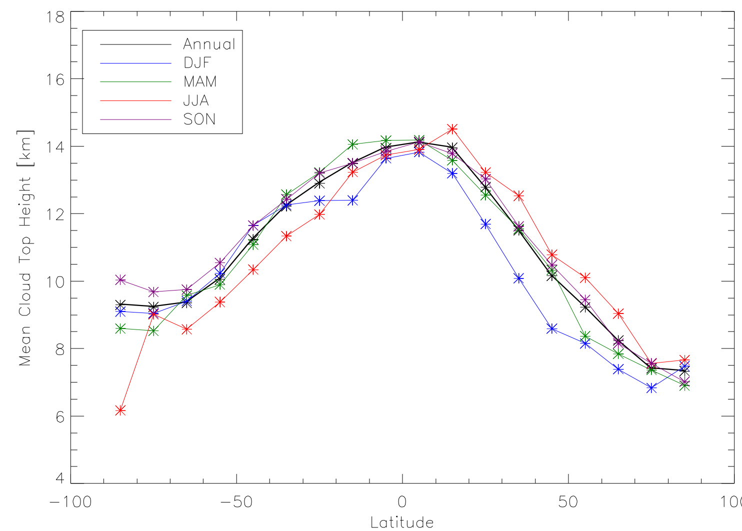
What do we want to know (Big)?

- Macro physical properties
  - Frequency of occurrence
  - Cloud height
  - Cloud thickness
    - Optical thickness
  - Cloud horizontal extent

Cirrus Climatology

Using the PACT Method and MIPAS Level 1 data for January through December 2003, a cirrus climatology was formulated:



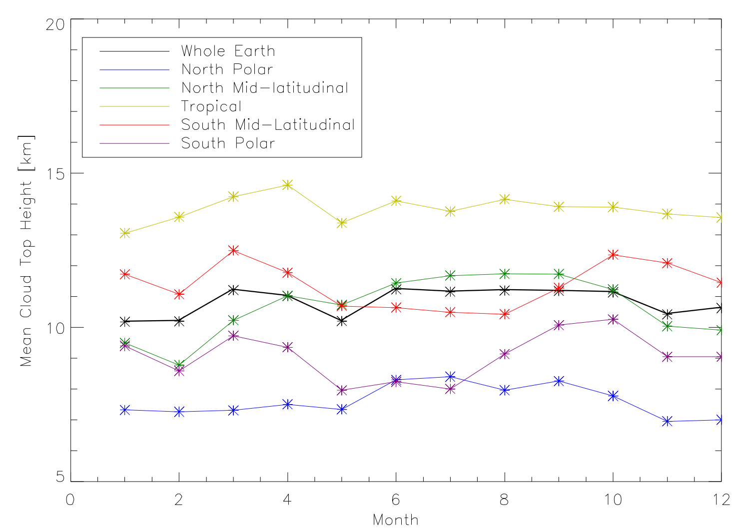


Cirrus cloud top heights retrieved seem sensible:

→ average cirrus cloud top height increases towards the equator, with increasing tropopause height;

→ a “hot spot" of high cirrus clouds over Indonesia, due to strong convection;

→ high cirrus over the southern Andes due to orthographic lift of prevailing westerly winds off the Pacific Ocean.



What do we want to know (Small)?

- Microphysical properties
  - Cloud phase (water/ice)
  - Cloud temperature
  - (In cloud trace gas concentrations e.g. HNO_3)
  - Drop size distribution
  - Crystal shape
  - Crystal size distribution
  - Spectral extinction coefficient

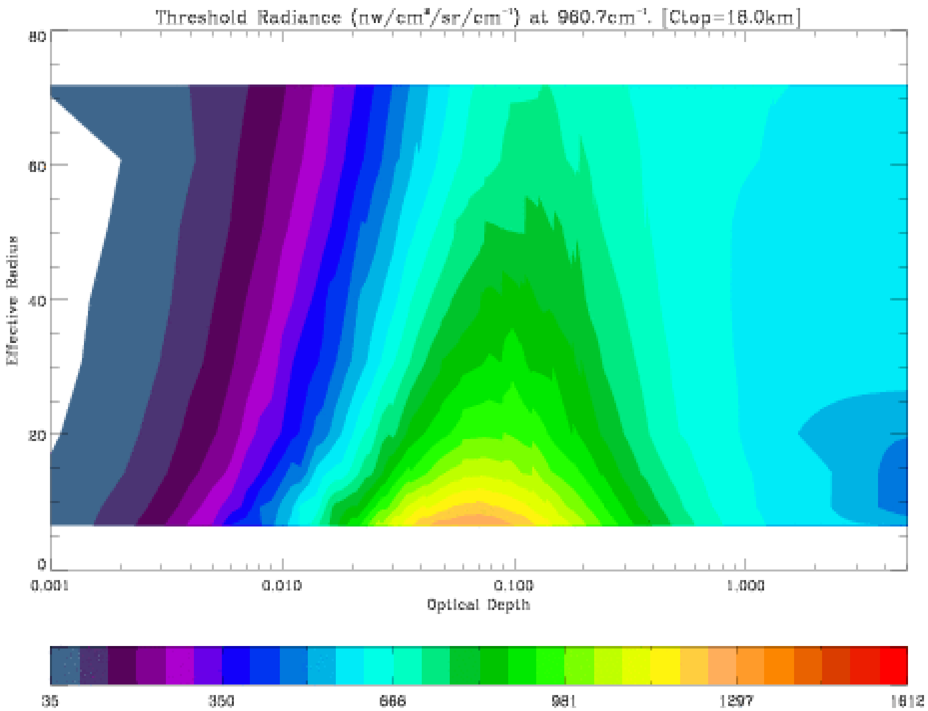
Challenges

- Cloud identification – will always miss a bit.
- Scattering of photons into the line-of-sight

Opportunities

- High resolution: Convective overshooting of cloud into the lower stratosphere
- Sensitivity to very thin cloud ($\tau \sim 0.003$)
- Linking into other A-train observations (MLS, Cloudsat, Calipso, MODIS)
- Compare and contrast with MIPAS results

Modelling Detection Sensitivity



- Detection threshold at 960.7 cm^{-1}
- MIPAS can be expected to detect cirrus of optical depths ~0.003
- Optically thin cloud has warm photons from lower in the troposphere scattered into the line of sight
- Peak in radiance at an optical depth of ~0.1
- As the cloud becomes optically thicker the radiance decreases as the satellite is only seeing the colder photons from the cloud top

Cloud Top Height Retrieval

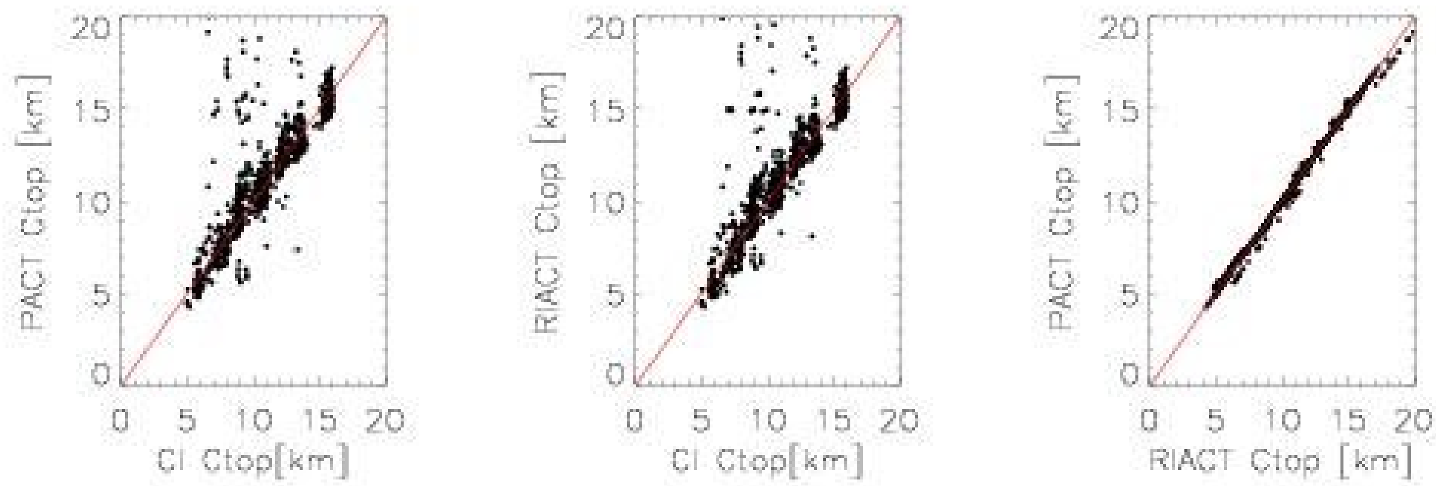
From MIPAS level 1 spectra, the cloud top height may be retrieved using conceptually simple methods:

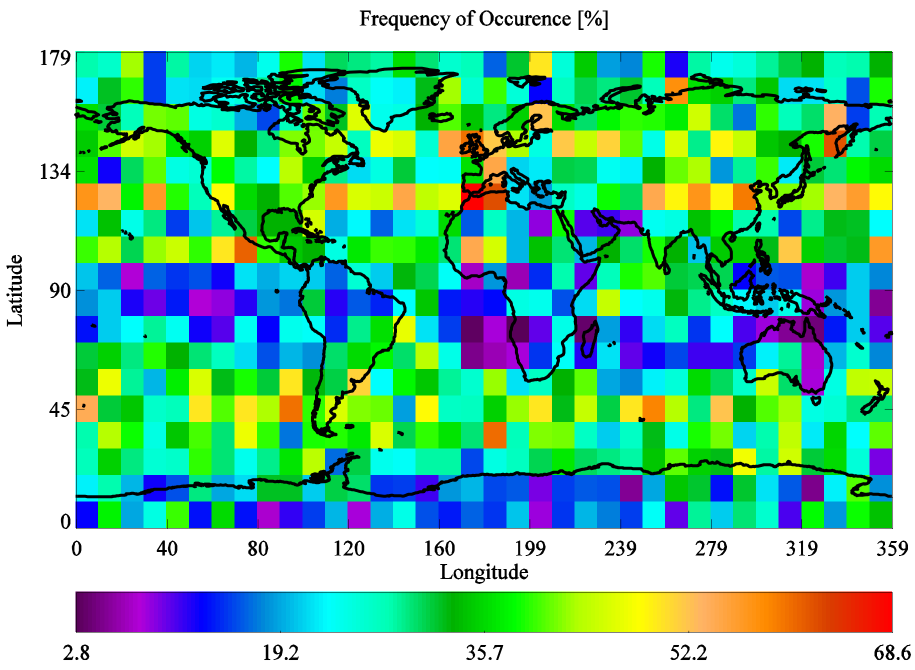
→ Use CI Method in the A band to detect cloud in a scan sequence of a MIPAS profile

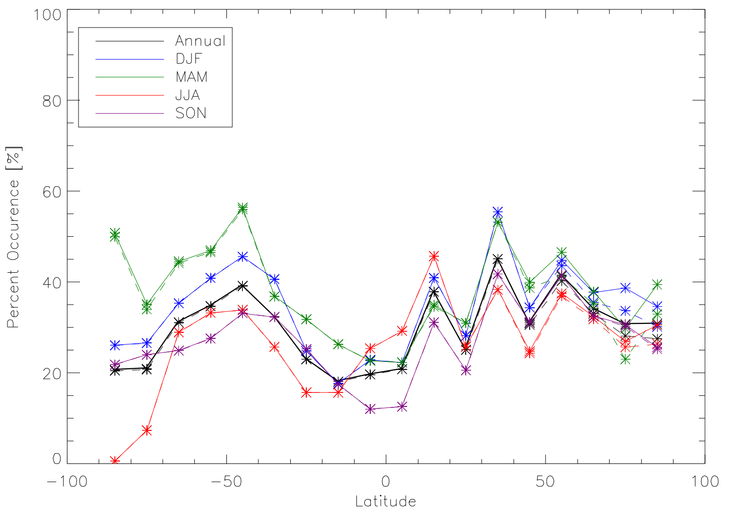
→ Assume cloud is homogeneous, thick and can estimated as a blackbody at temperature T_B.

→ Use either PACT (**P**lanck **A**pproximation for **C**loud **T**op Height) Method (Planck function models measured radiance) or RIACT (**R**FM **A**pproximation for **C**loud **T**op Height) Method (RFM modelled radiance emission) to iteratively locate the cloud top height by moving a virtual cloud top upwards through the instrument field of view at the identified cloudy tangent height.

→ Both Methods yield nearly identical results, with a precision of 0.250 m.

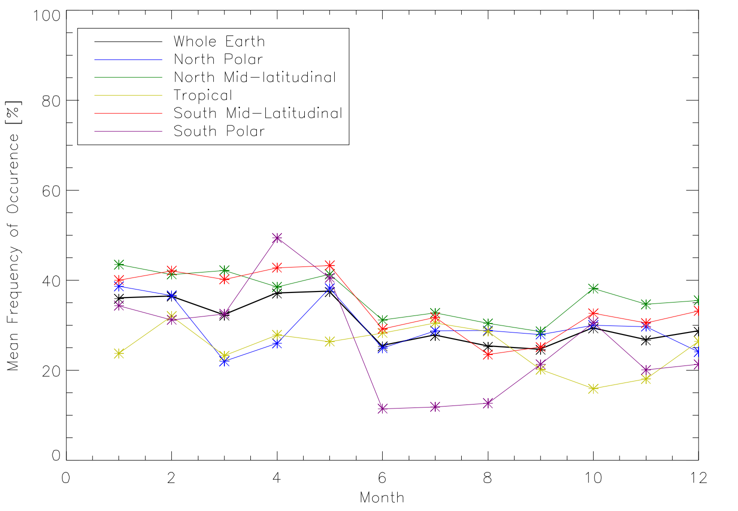




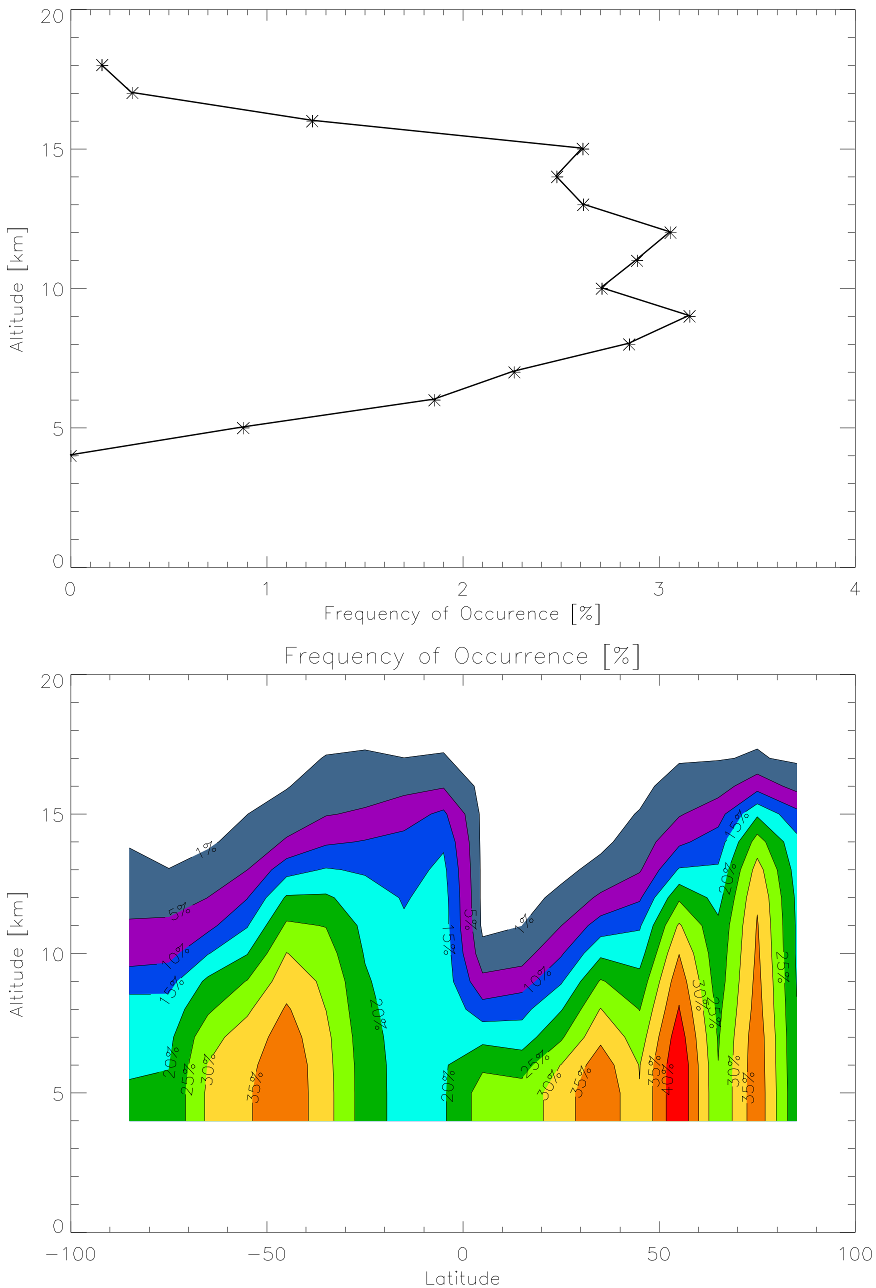


Frequency of occurrence of cirrus clouds also corresponds to what is expected:

→ cirrus are most prevalent in the mid-latitudes and tropics, and then frequency of occurrence shows distinct minima located at 20º - 30º on each side of the equator



→ mean cirrus cloud frequency of occurrence should be more or less constant over time at about 30%



There appears to be a relation between cloud frequency and cloud top height:

→ Reassuring that cirrus only retrieved in altitude range that typically thought to occur observationally.

→ Integrating over altitude gives a total global frequency of occurrence of ~30%, as expected (top figure).

→ Tri-peaked structure attributable to dominant cloud top heights in certain latitudes (see bottom figure).

→ Lowest peak (9 km) attributed to cirrus clouds at ±60^{o};

→ Middle peak (12 km) attributed to cirrus clouds at ± 40^{o};

→ Highest peak (15 km) attributed to cirrus clouds at equator.