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 $\sim$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 $\sim$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 (Planck Approximation for Cloud Top Height) Method (Planck function models measured radiance) or RIACT (RFM Approximation for Cloud Top 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 20° - 30° 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 \( \sim 30\% \), 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 \( \pm 60^\circ \);

   → Middle peak (12 km) attributed to cirrus clouds at \( \pm 40^\circ \);

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