Limb cloud flagging
Sciamachy ClOud Detection Algorithm (SCODA)

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Contents:

- ➢ **Summary of Approach**
- ➢ **Status/Input for processing**

Limb Cloud Flagging

Color index (CI) approach:

Difference in relative contributions of scattering by air molecules (*Rayleigh scattering*) and the cloud particles (*Mie sattering*) at two different wavelengths

Considerations:

- Radiation < 400 nm not used (atmosphere optically thick for scattering in the upper troposphere)
- Windows with strong molecular absorptions not used
- Radiation ~ NIR used to distinguish the thermodynamic phase (spectral dependence of absorption differ appreciably between ice and water ~1670 nm)

SCODA Algorithm:

1- Color index profile (CI):

Ratios of spectrally integrated intensities in a defined wavelength band

$$R_c(TH) = \frac{I(\lambda_1, TH)}{I(\lambda_2, TH)}$$

Sensivity to cloud determination

2- Color index ratio (CIR):

Starting from the lowest TH, pairs of two adjecent color indices divided, maximum shows the cloud top height (CTH)

$$\Theta(TH) = \frac{R_c(TH)}{R_c(TH + \Delta TH)}$$

$\Delta TH = 3.3$ km

SCODA is part of operational retrieval chain since SCIAMACHY data Lv2 V5.04 (support to operational limb trace gas retrieval)

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SCODA Clouds Types:

- Tropospheric (Water & Ice)
- Polar stratospheric (PSCs)
- Noctilucent (NLCs, North)

Wavelength (bands) ratio:

Noctilucent clouds:

265nm & **291nm**

Cloud detection (water):

750nm & 1090nm

Phase determintion (ice):

1550nm & **1685nm** (IUP)

1550nm & 1630nm (Operational)

In addition limb water vapour retrieval at IUP uses 1550/1090 nm for cloud detection.

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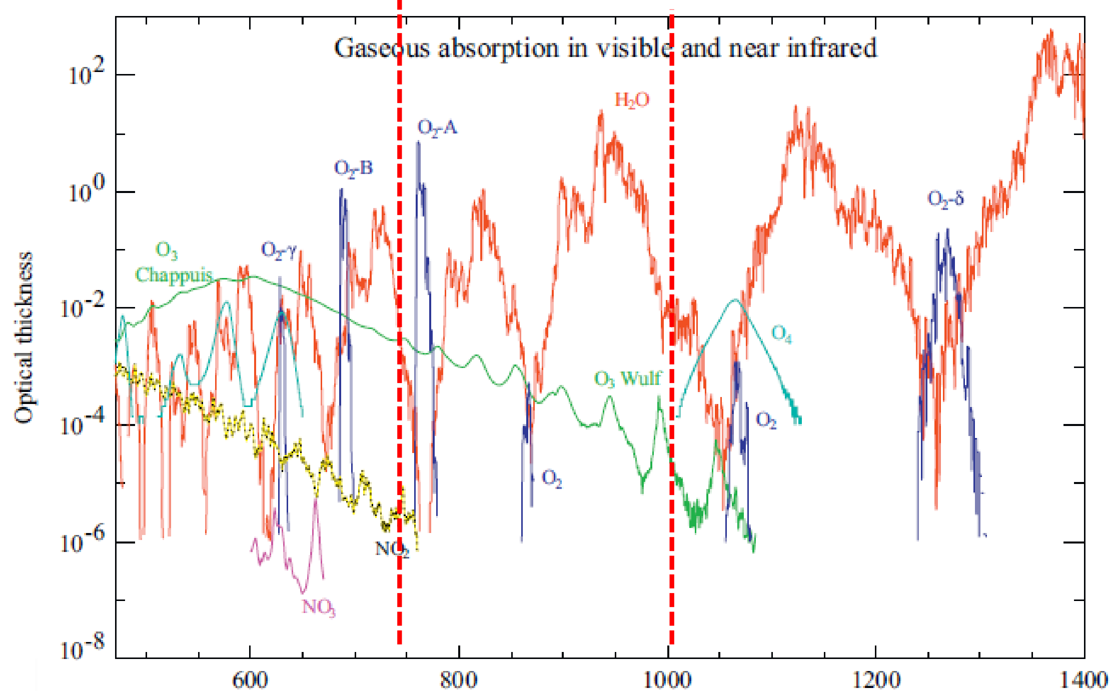
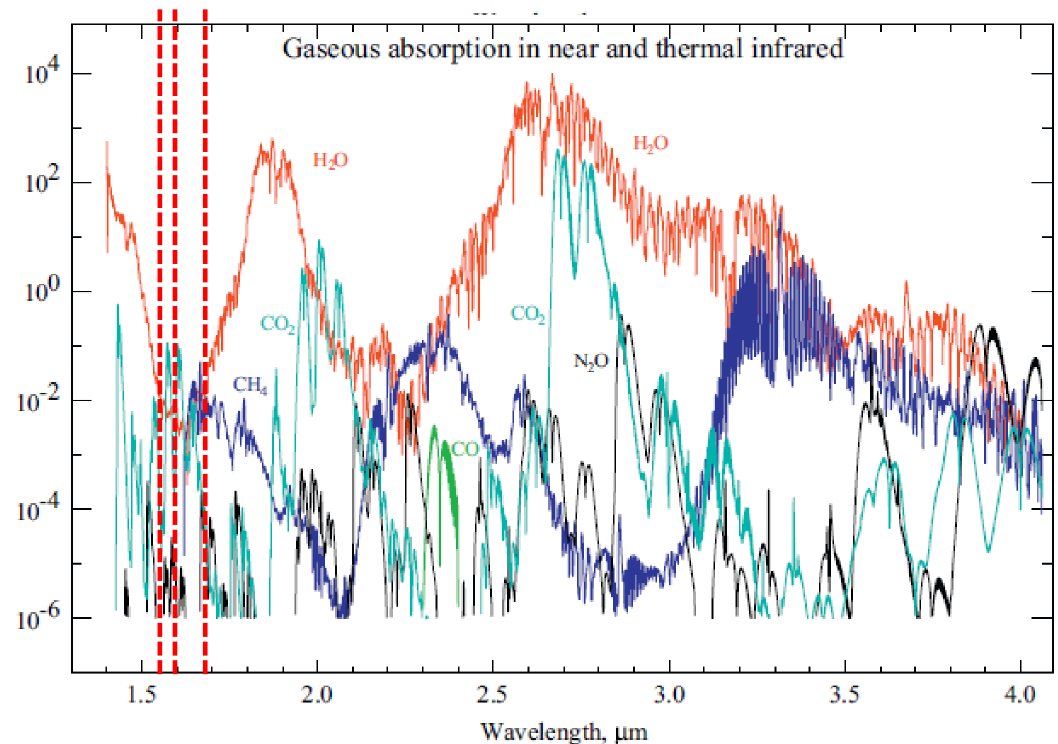




Rozanov V. V. et al., jqsrt 2014

SCODA flags (Operational processor):

Cloud type	CIR	Threshold	Flag	Description
Normal (water)	1090nm/750nm	CIR<1.4	0	No clouds
		1.4<CIR<2	1	Partial
		CIR>2	2	Full
		CIR>>	3	Bad data or >> Max. TH
PSCs	1090nm/750nm	CIR<1.3, lat.> 50°, 15<TH<30	0	No PSCs
		CIR>1.3, lat.> 50°, 15<TH<30	1	PSCs
**Ice	1630nm/1550nm	**CIR?**	**0**	**Water cloud**
		CIR>??	1	Ice cloud
		TH >> or ??	2	Bad data (>> Max.TH)

** ***Thresholds not specified in* SGP OL1b-2 ATBD Version 6**

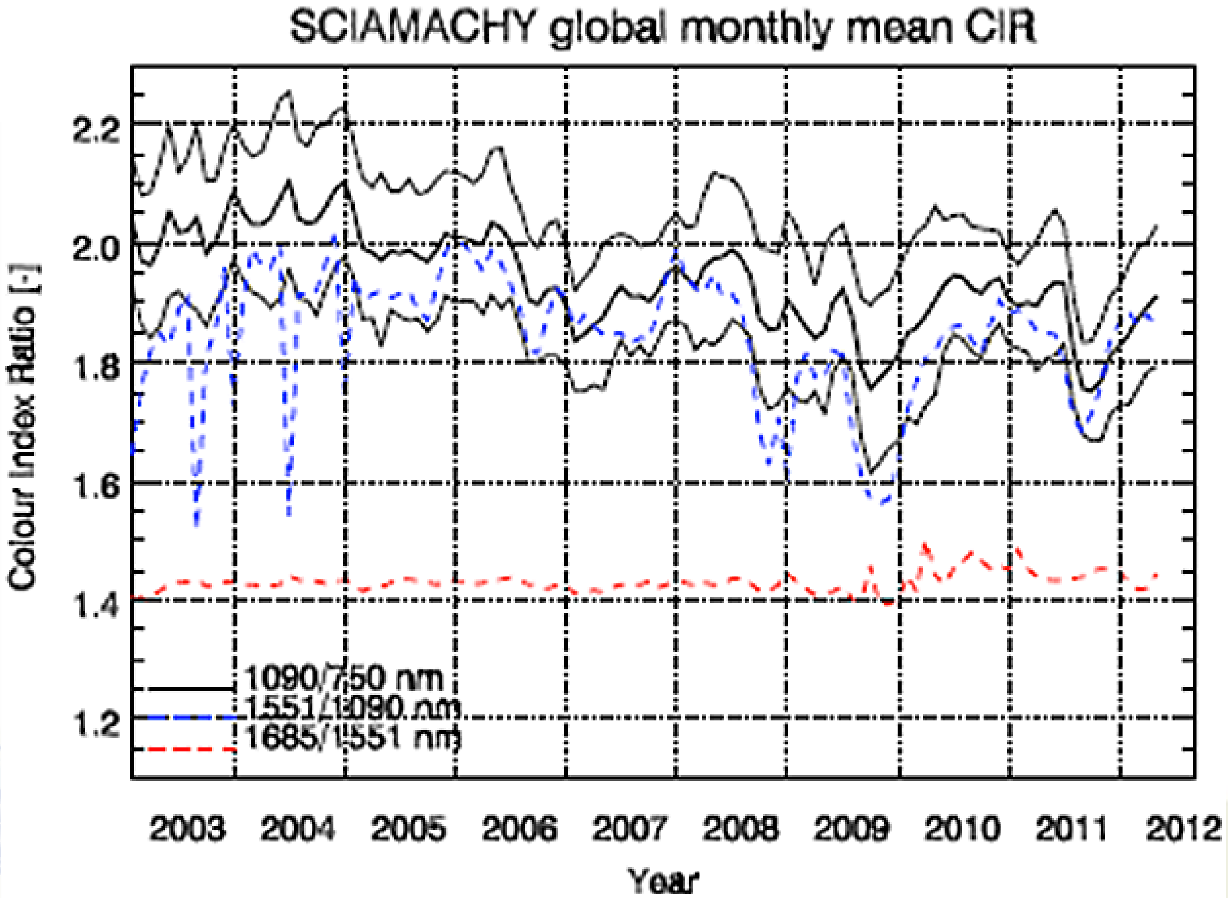
Limb Cloud flagging optimization:

- **Improvement in detection sensivity:** Optimize phase detection, issues as S/N decreasing with altitude, bad pixels in channel 6+
- **Distinguish aerosols from clouds:** CIR 1090/750 misidentifies high aerosol layers as clouds, CIR ~1670/1550 almost not effected

2008, 2009 and 2011
→Volcanic eruptions

2003, 2004 and 2008
→ Decontamination phases

Eichmann K. U. et al 2015, submitted amt



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Clouds discrimination Study

CI instead of CIR:

- Ratio of reflectance 1550/1670 (here normalized by Rayleigh reflectance, albedo=0), ratios improve on S/N

  Note: 1670 +- 20 nm window is used, bad and RTS pixels flagged in real data

- At a given TH if ratio < 0.7, cloud present at this TH or above. All THs between ground and 20 km scanned

  Flag:
  - All events with cloud detected between 0-20 km
  - Consecutively ignore lowest THs until 15 km, get all event with clouds between TH_i-20 km

- V7 used with calibration setting of V8, bad pixel mask from L1b is implemented

SCIATRAN Simulations (1550/1670, Rayleigh normalized)

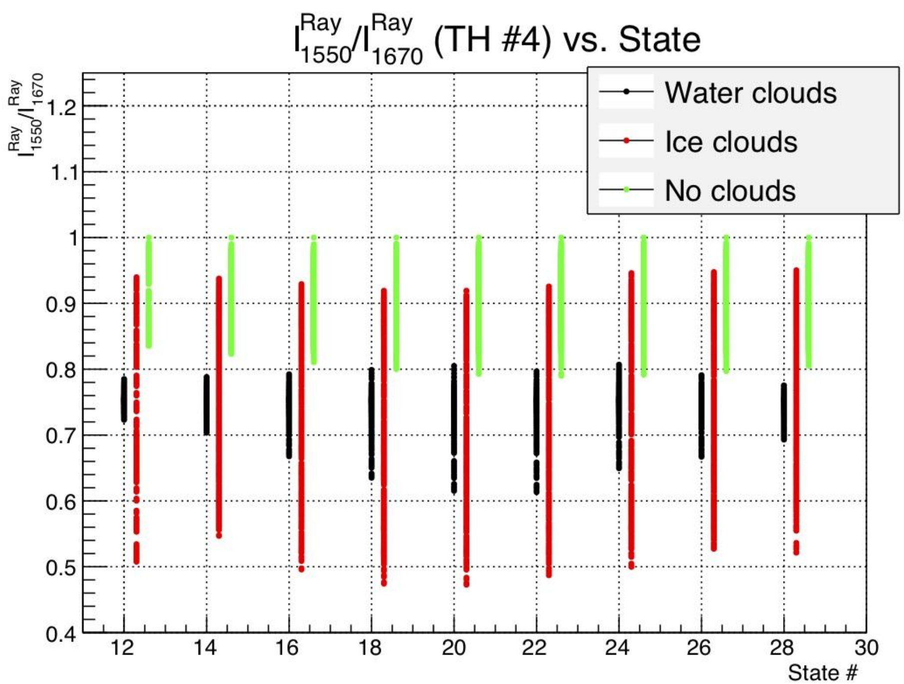
- 1 set with varying albedo/boundary layer/trop./stratospheric aerosol
- 1 set with clouds at different altitudes in addition

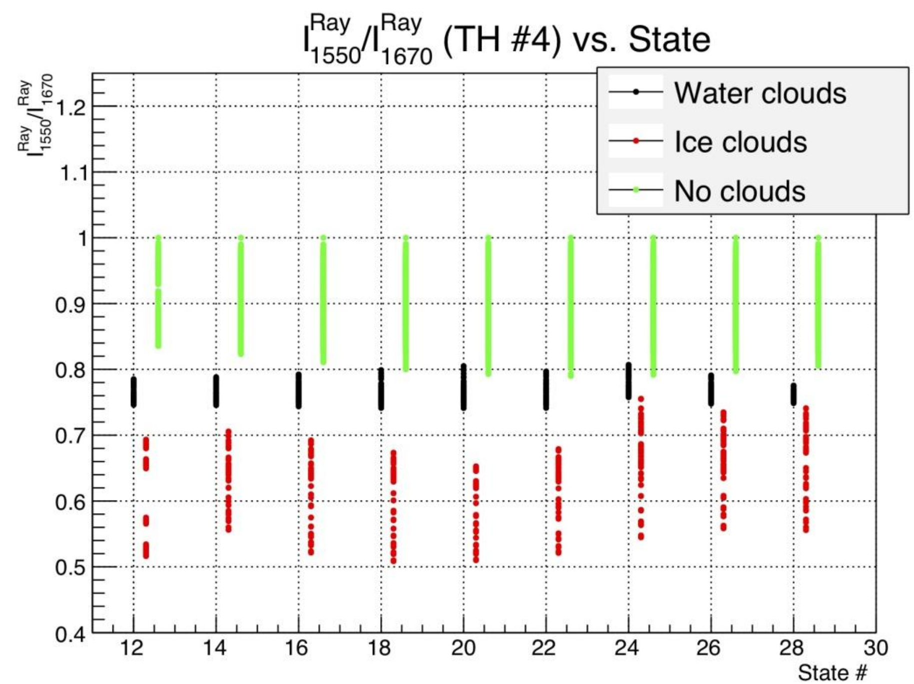
  Water clouds: 5-7, 9-11, 11-13, 13-15 km, OD=0.5-50

  Ice clouds: 13-15, 15-17, 17-19, OD=0.001-0.5

  Each with 2 different size parameters

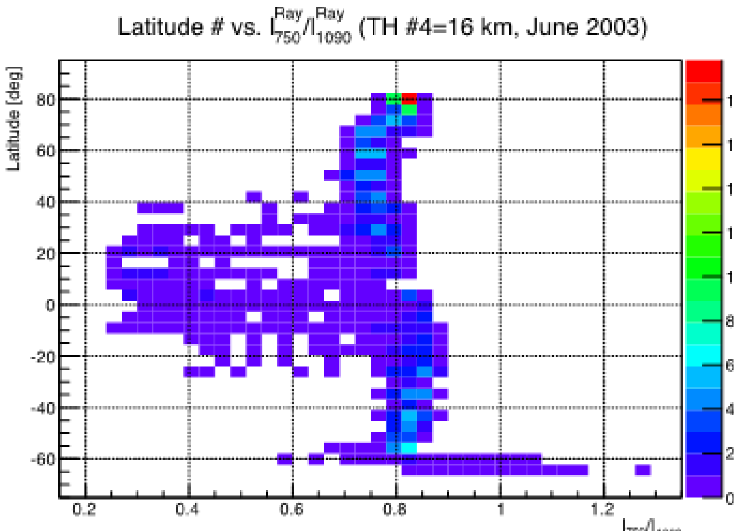
Discrimination is difficult unless similar background conditions and/or known OD

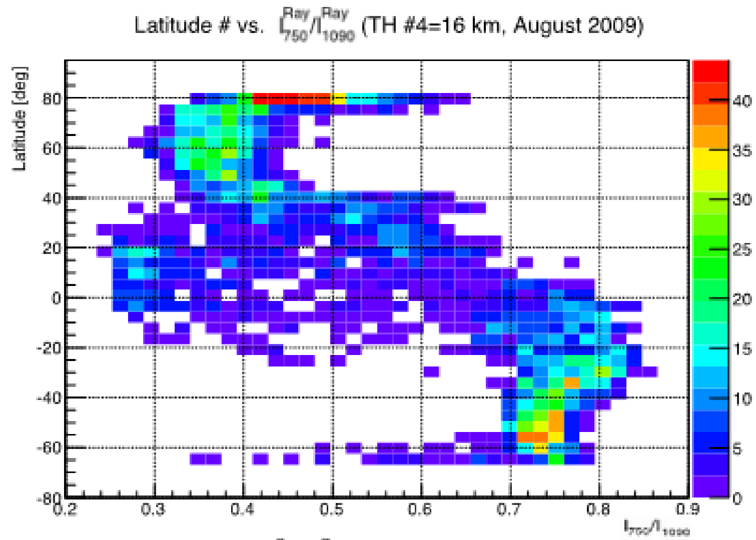




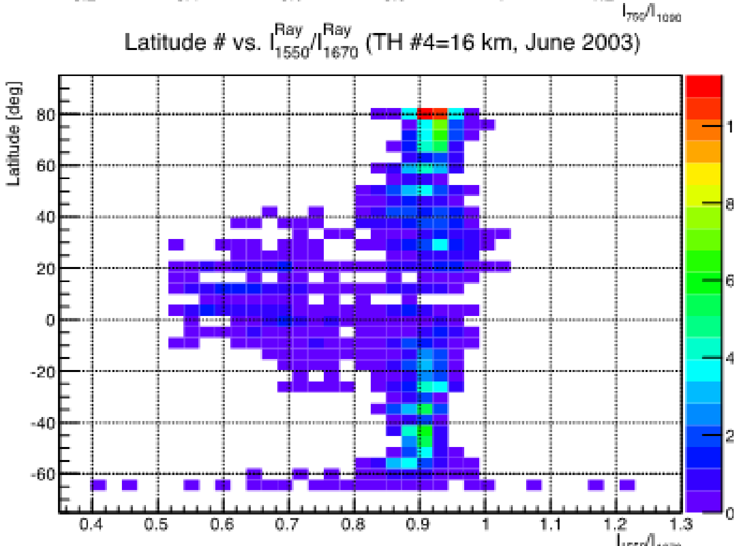
SCIAMACHY Limb data (ratio vs. lat.)

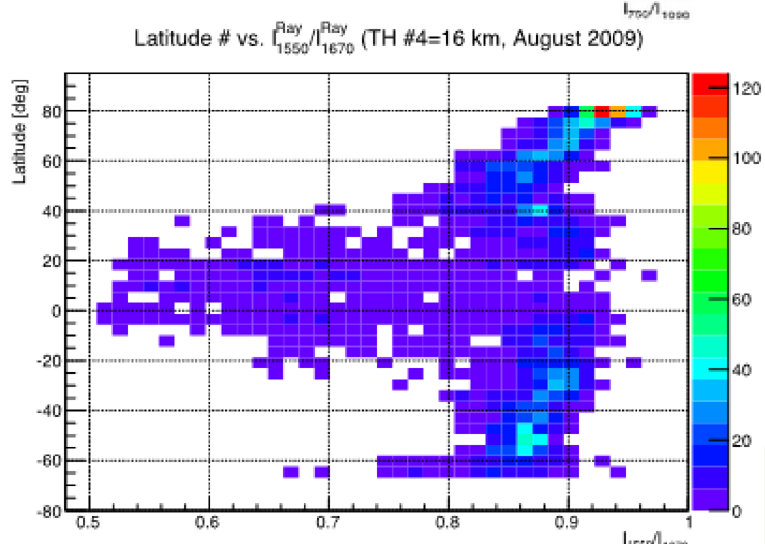
Rayleigh normalized ratio 750/1090 misidentifies high aerosol load as clouds, chages distribution (Sarychev eruption June, 2009), 1550/1670 uneffected





750/1090 nm



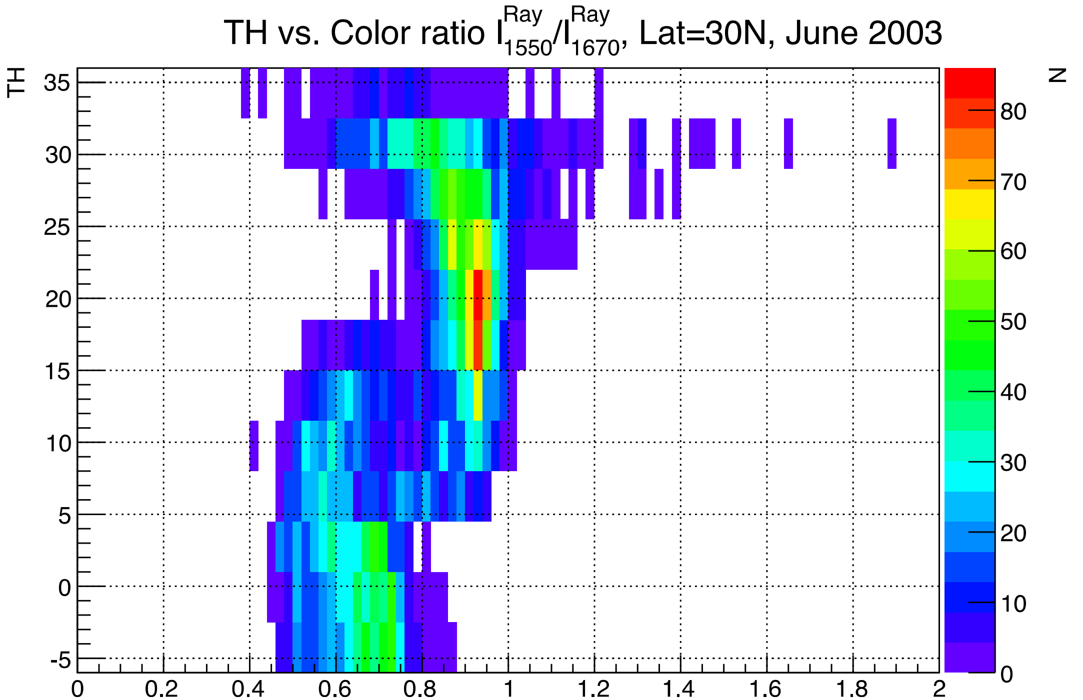


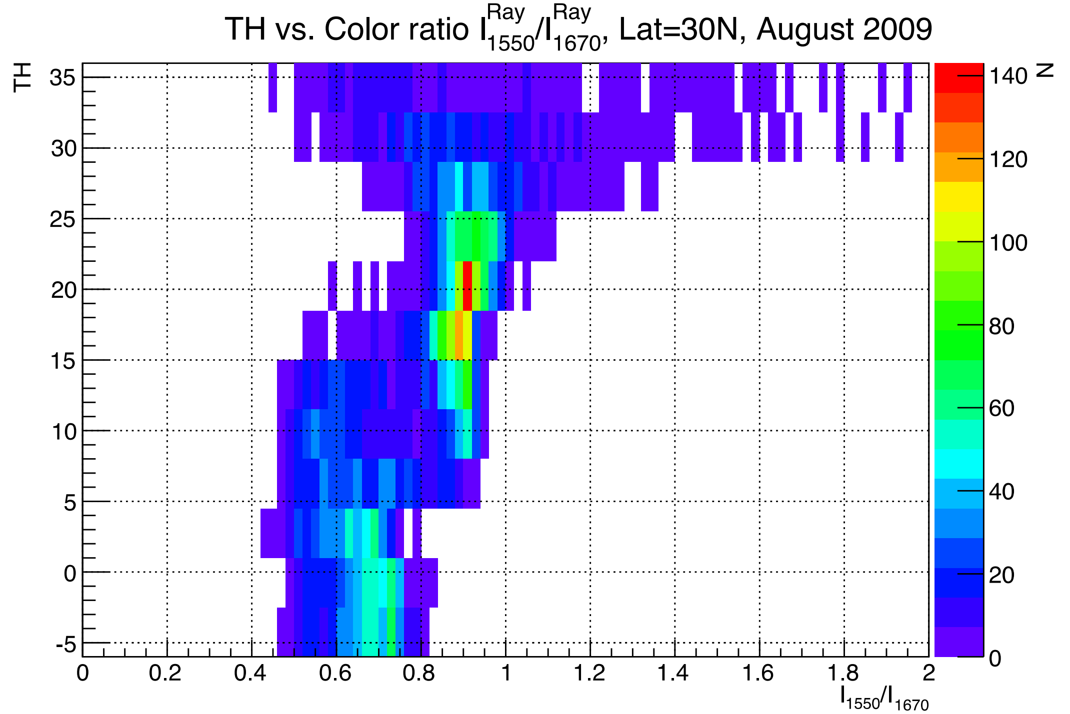
1550/1670 nm

SCIAMACHY Limb data (ratio 1550/1670 vs. TH)

No qualitative difference between the two years, although aerosol load is much higher in 2009.

Differences from 30 km up.





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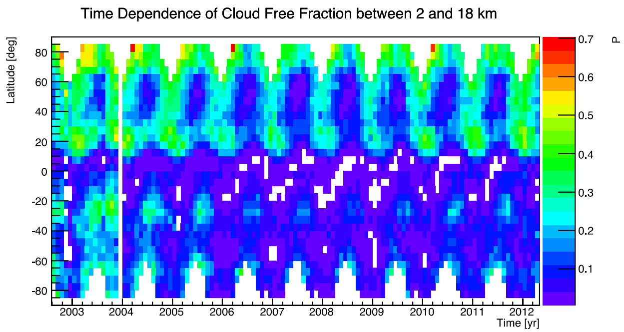
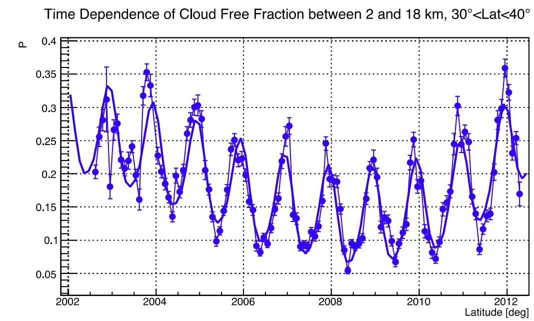
In addition

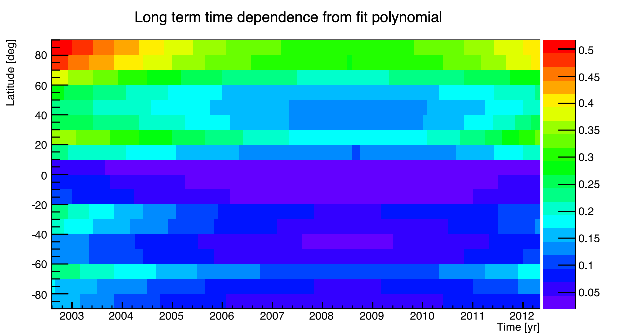
Cloud frequencies in Limb (monthly zonal means):

Fraction of cloud free profiles is strongly time/lat dependent

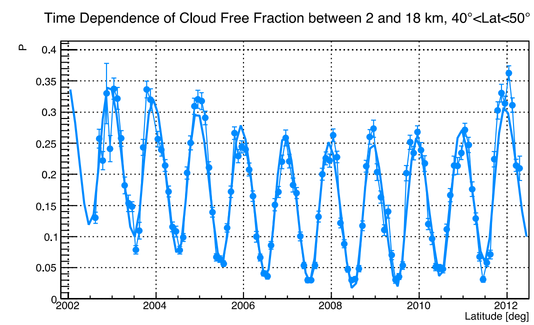


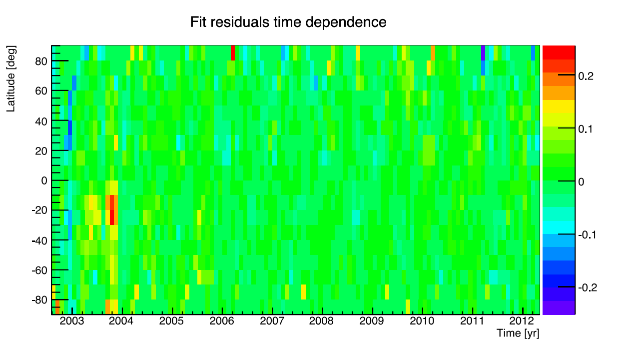
30N – 40N



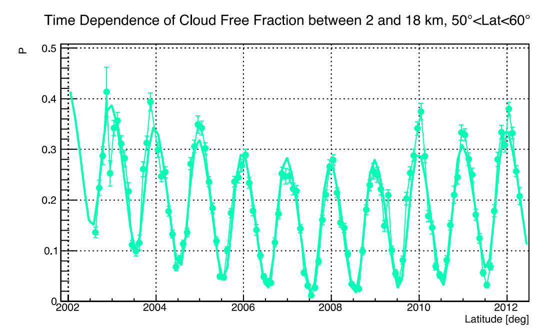


40N – 50N

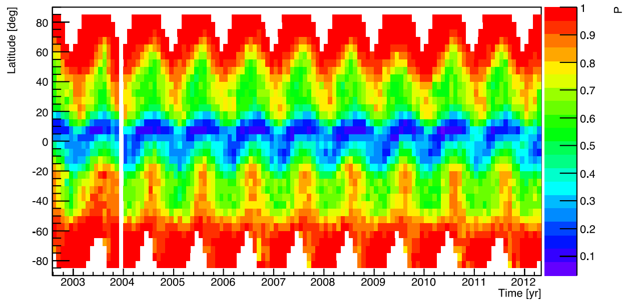




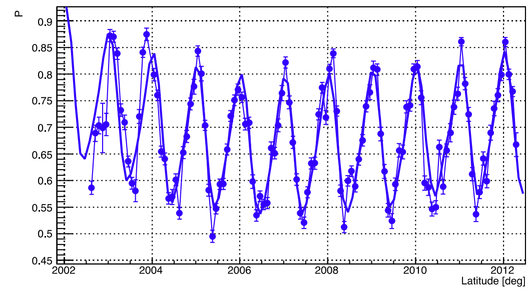
50N – 60N



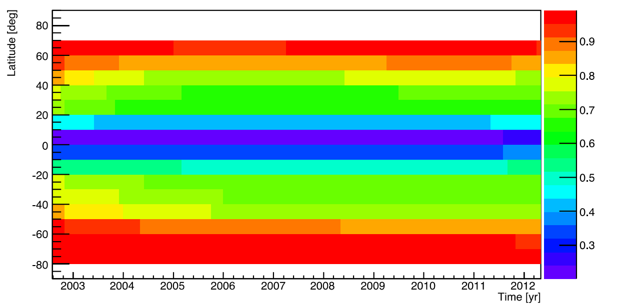
Time Dependence of Cloud Free Fraction between 12 and 18 km



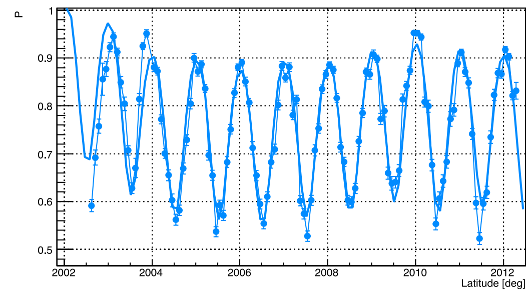
Time Dependence of Cloud Free Fraction between 12 and 18 km, 30°<Lat<40°



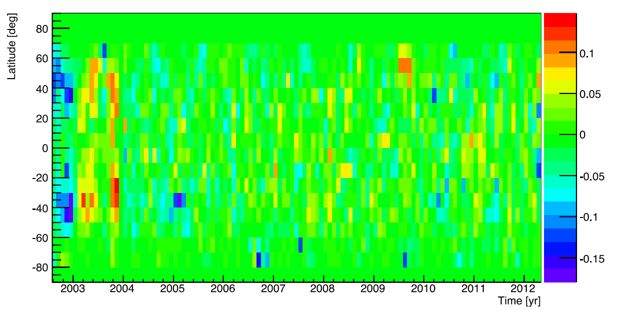
Long term time dependence from fit polynomial



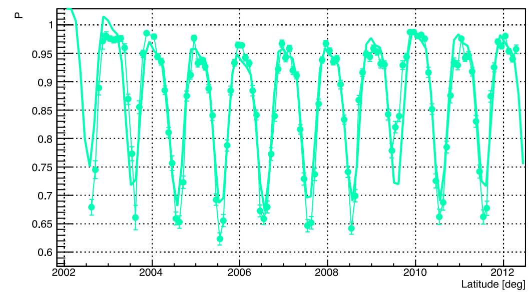
Time Dependence of Cloud Free Fraction between 12 and 18 km, 40°<Lat<50°



Fit residuals time dependence



Time Dependence of Cloud Free Fraction between 12 and 18 km, 50°<Lat<60°



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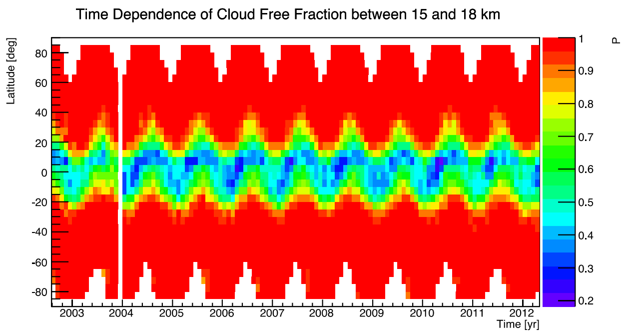
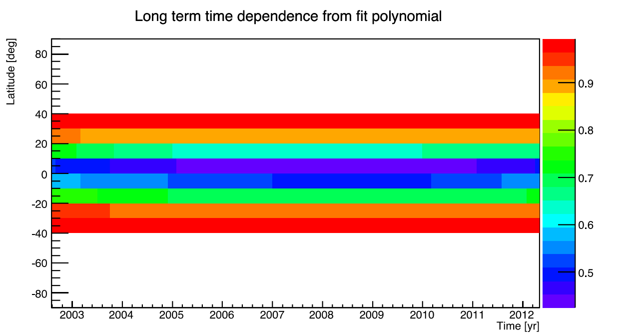
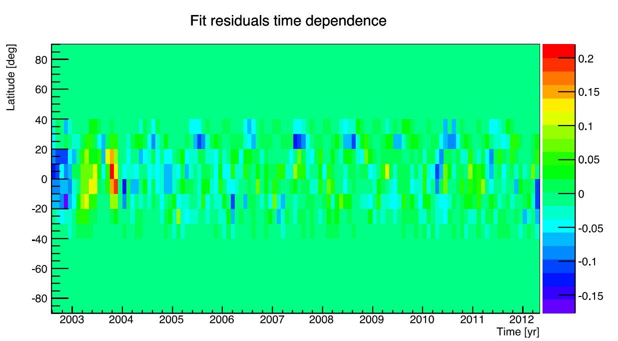
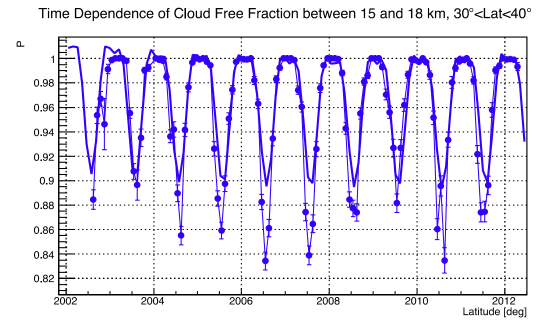
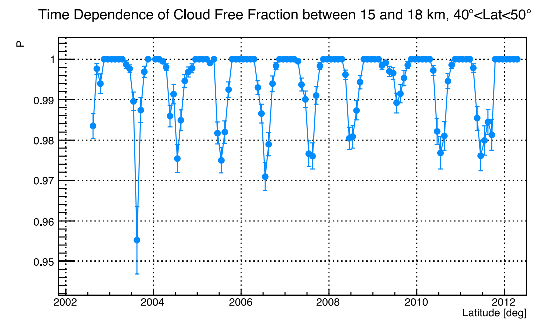

Time Dependence of Cloud Free Fraction between 15 and 18 km
Latitude [deg]
Time [yr]
P


Long term time dependence from fit polynomial
Latitude [deg]
Time [yr]


Fit residuals time dependence
Latitude [deg]
Time [yr]


Time Dependence of Cloud Free Fraction between 15 and 18 km, 30°<Lat<40°
P
Latitude [deg]


Time Dependence of Cloud Free Fraction between 15 and 18 km, 40°<Lat<50°
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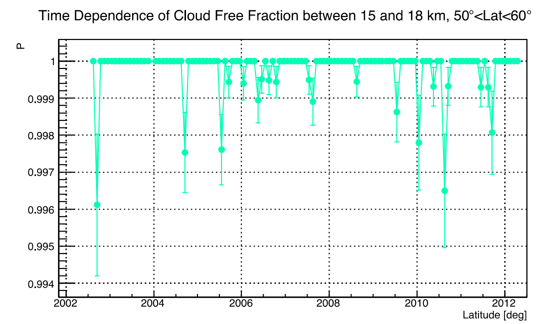
Latitude [deg]


Time Dependence of Cloud Free Fraction between 15 and 18 km, 50°<Lat<60°
P
Latitude [deg]

Several issues when analyzing time series:

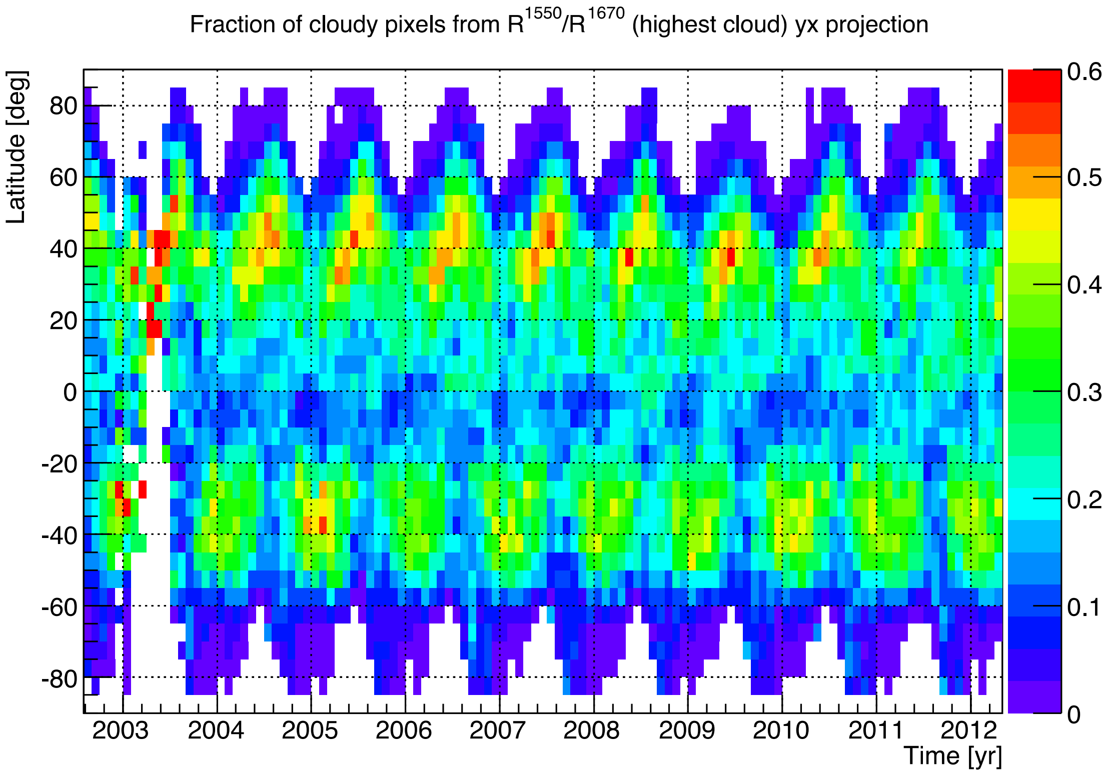
- **Degradation/background:** wrong degradation or offset correction could shift the distribution (changing purity and efficiency of samples)
- **Tangent height sampling**
- **Noise** (gets worse if dark currents increase)
- Though 1550/1670 ratio is less sensitive to aerosols than the 750/1090, there is some sensitivity

Effect of different flagging:

only flag the highest TH where the cloud is detected, R<0.75, cloudy fraction

Still strong time dependence

TH 11-12 km



Possible hick ups:

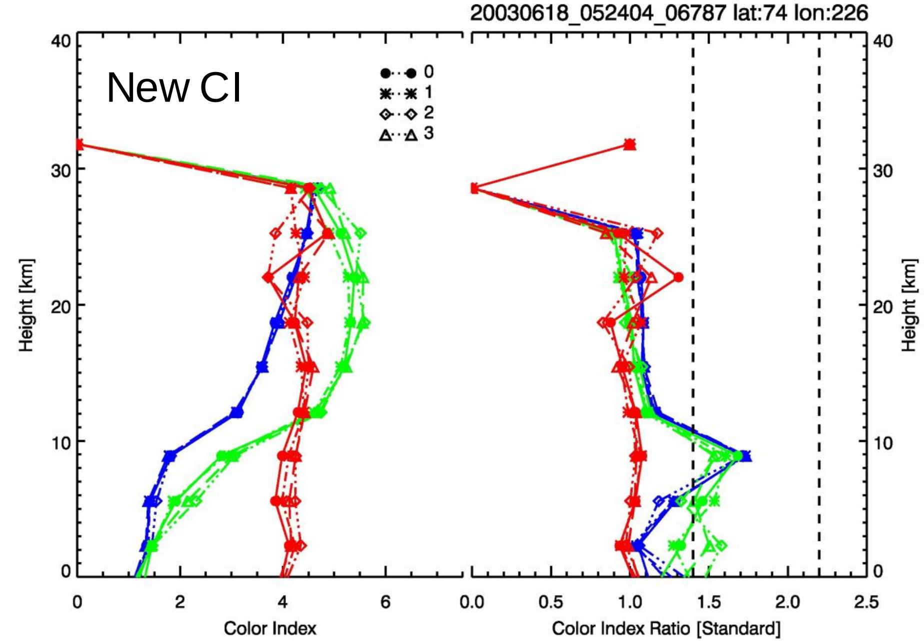
- decontaminations 2002-2004
- TH sampling variations in 2002/2003
- Orbit change (TH scanning regime)
- Volcanic eruptions

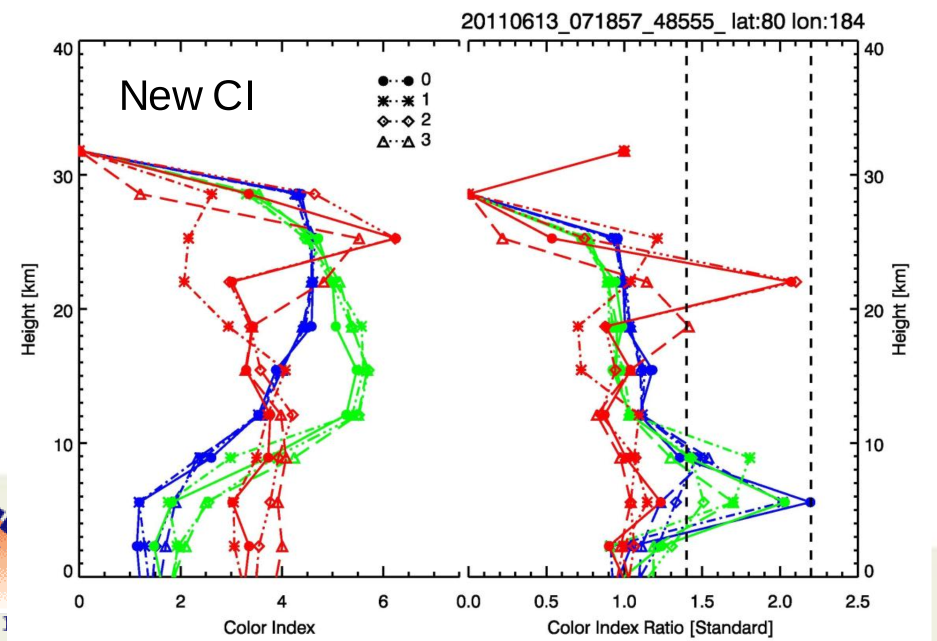
Latitude dependence may be improved by polarization calibration application for certain limitations

Investigations ongoing:

- Sensivity of Ratios (profiles)
- Threshold optimization
- Ratios with out Rayleigh normalization
- To try the ratio 1050 & 1250 (equidistant from water vapour absorption band)

1090 & 1050 750 & 1090 1550 & 1670





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Conclusions:

- 750/1090 nm ratio is not able to distinguish clouds and high aerosol load but 1550/1670 nm ratio can
- Without independent retrieval of OD it may be extremely difficult to distinguish water and ice clouds while still separating clouds/aerosols *(needs more effort and time)*
- Additional pitfall:

  TH sampling – it is possible to miss geometrically small and/or optically thin clouds
- Time series analysis show strongly time/lat dependence, may be improved to some extent by switching on polarization calibration (*applicable*)
- Switching to CI instead of CIR in the cloud flagging algorithm is straight (thresholds need to be optimized).

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