# First SCIAMACHY Limb Results

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Vladimir Rozanov, Heinrich Bovensmann, and John. P. Burrows
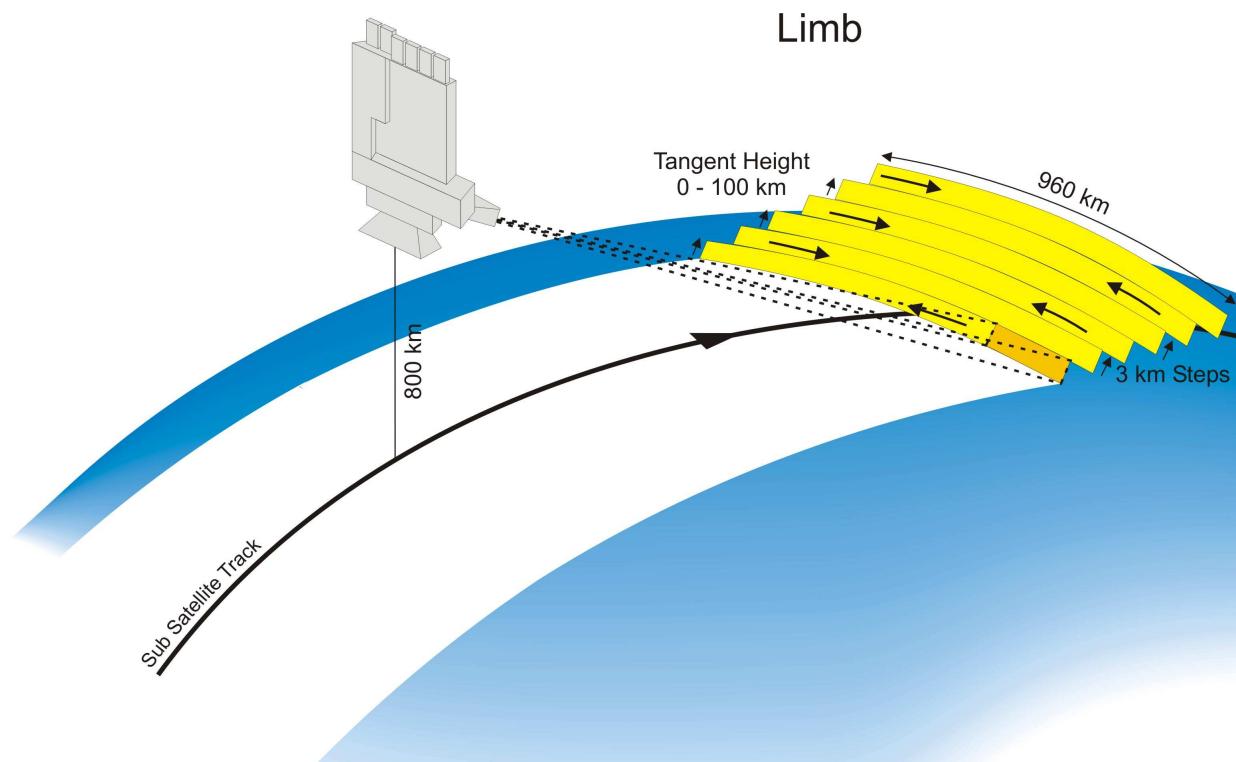
Institute of Environmental Physics/Remote Sensing (iup/ife)
University of Bremen

## Outline

- Stratosphere:
  - Retrievals: $O_3$, $NO_2$, BrO
  - Detection of PSCs
- Mesosphere:
  - Retrieval of $O_3$ profiles
  - Detection and mapping of NLCs

# SCIAMACHY Limb Geometry



- Vertical resolution: 2.6 km
- Horizontal resolution in azimuth direction: 240 km (120 km min.), 960 km swath
- Horizontal resolution in flight direction: approx. 400 km
- Observation optimised to match limb with nadir measurements
- Duration of Limb sequence: 60 sec.
- Global coverage: 6 days at the equator

# The limb as seen from the space shuttle
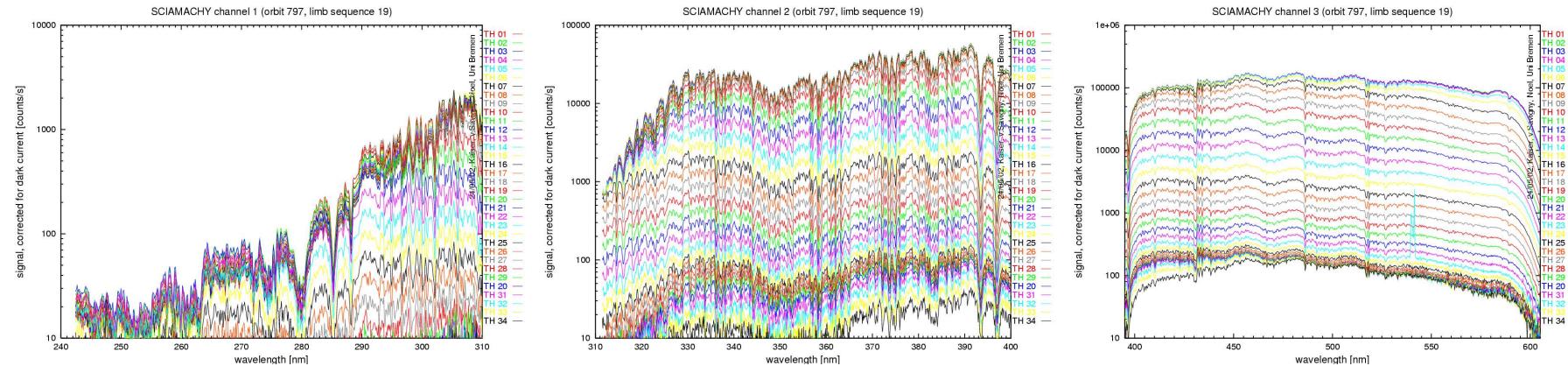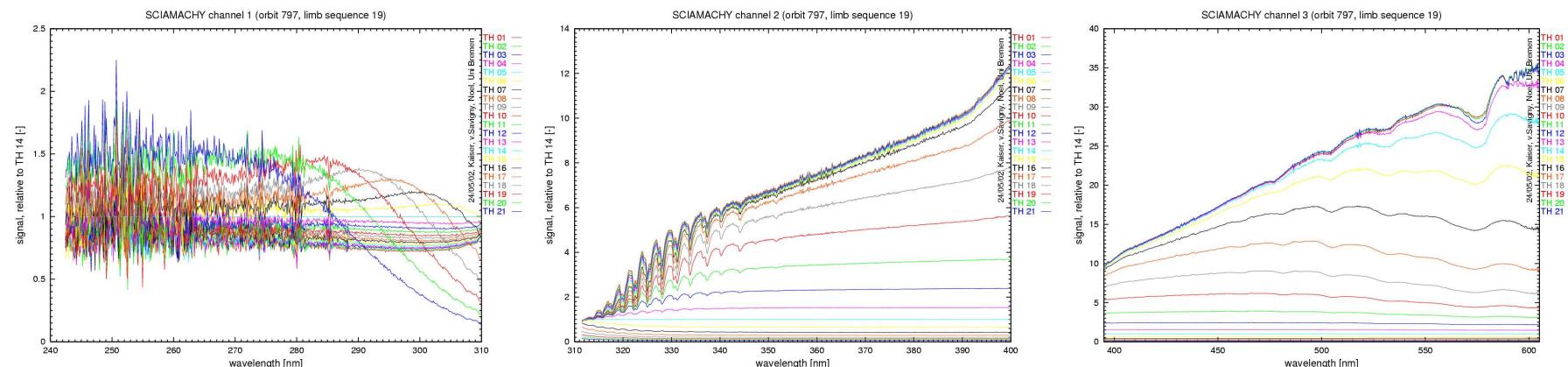
# Sample limb spectra – Channels 1-3

## Uncalibrated Level 0 limb spectra
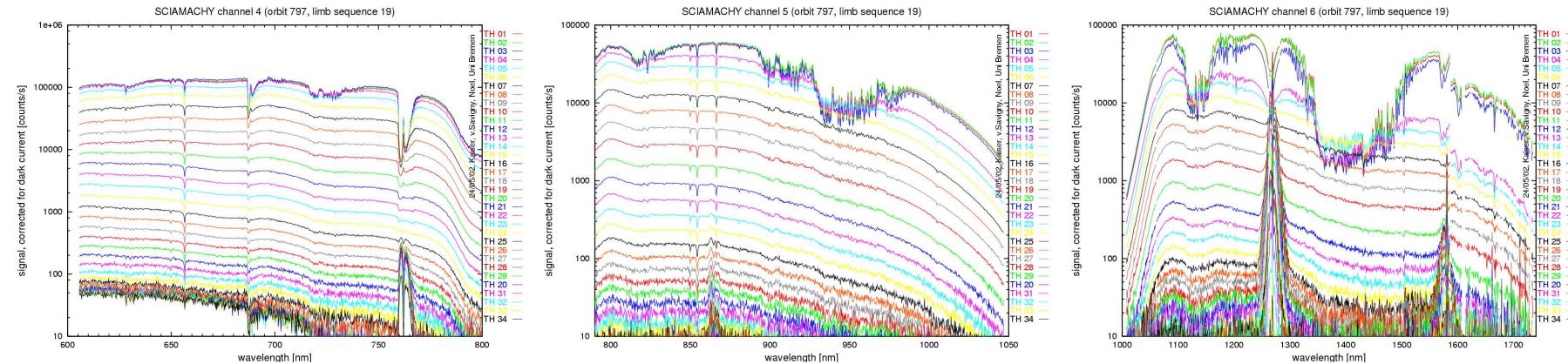


## Normalized (w.r.t. 44 km TH) limb spectra
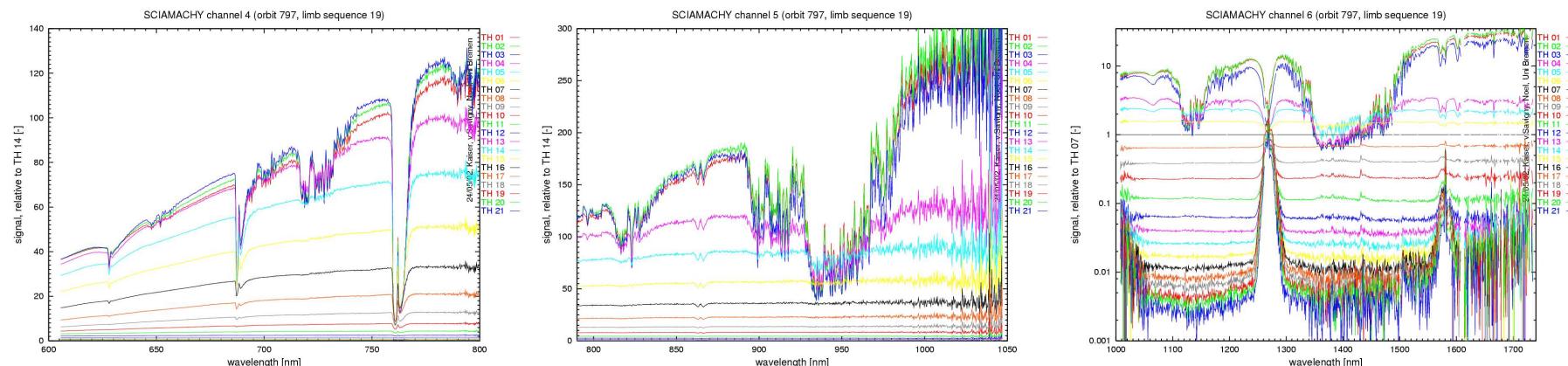
# Sample limb spectra – Channels 4-6
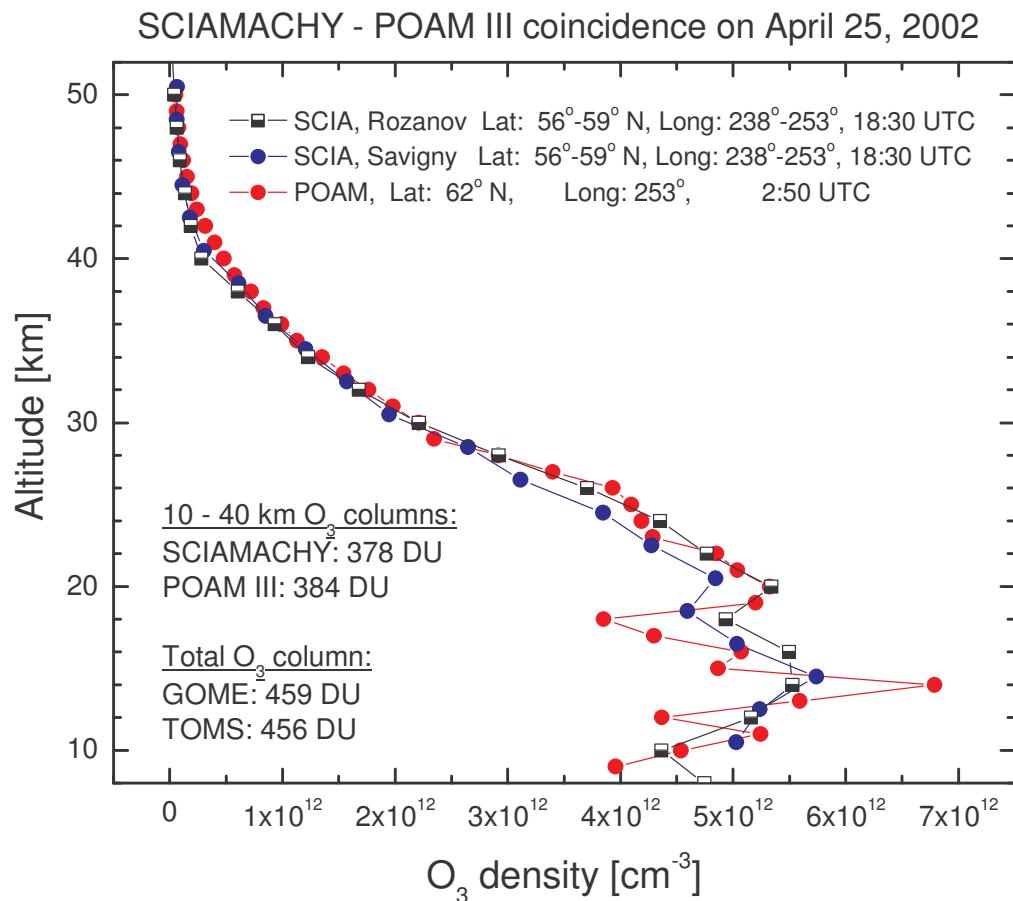
## Uncalibrated Level 0 limb spectra
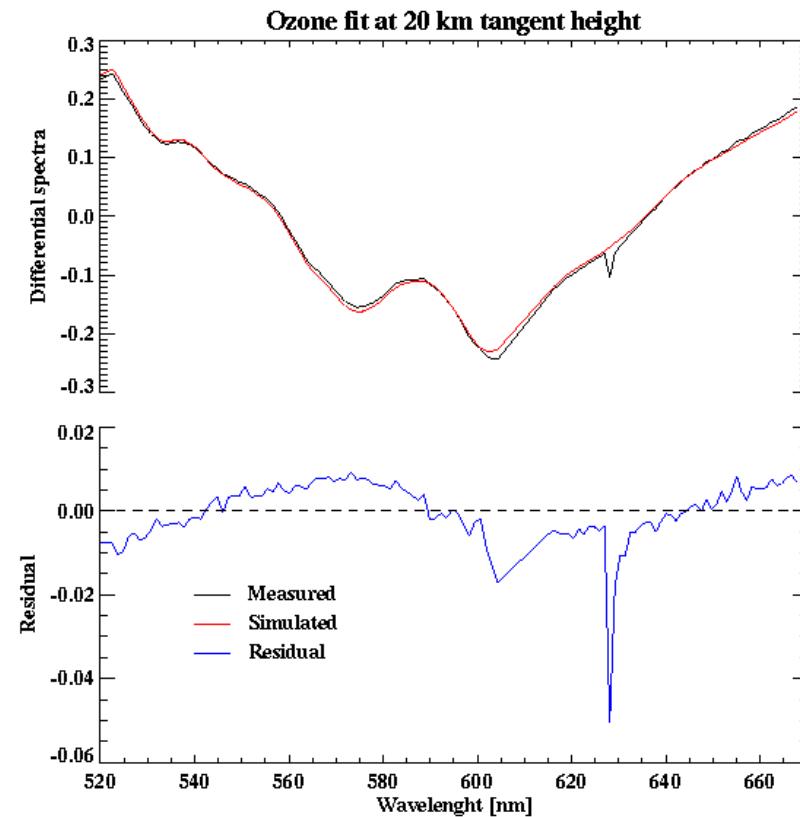


## Normalized (w.r.t. 44 km TH) limb spectra
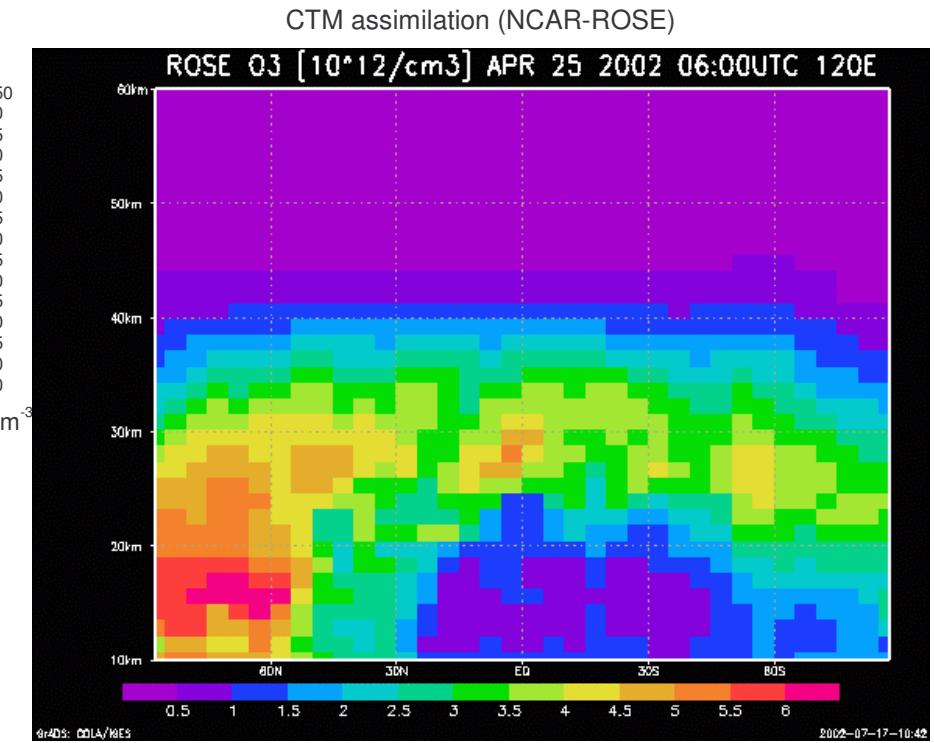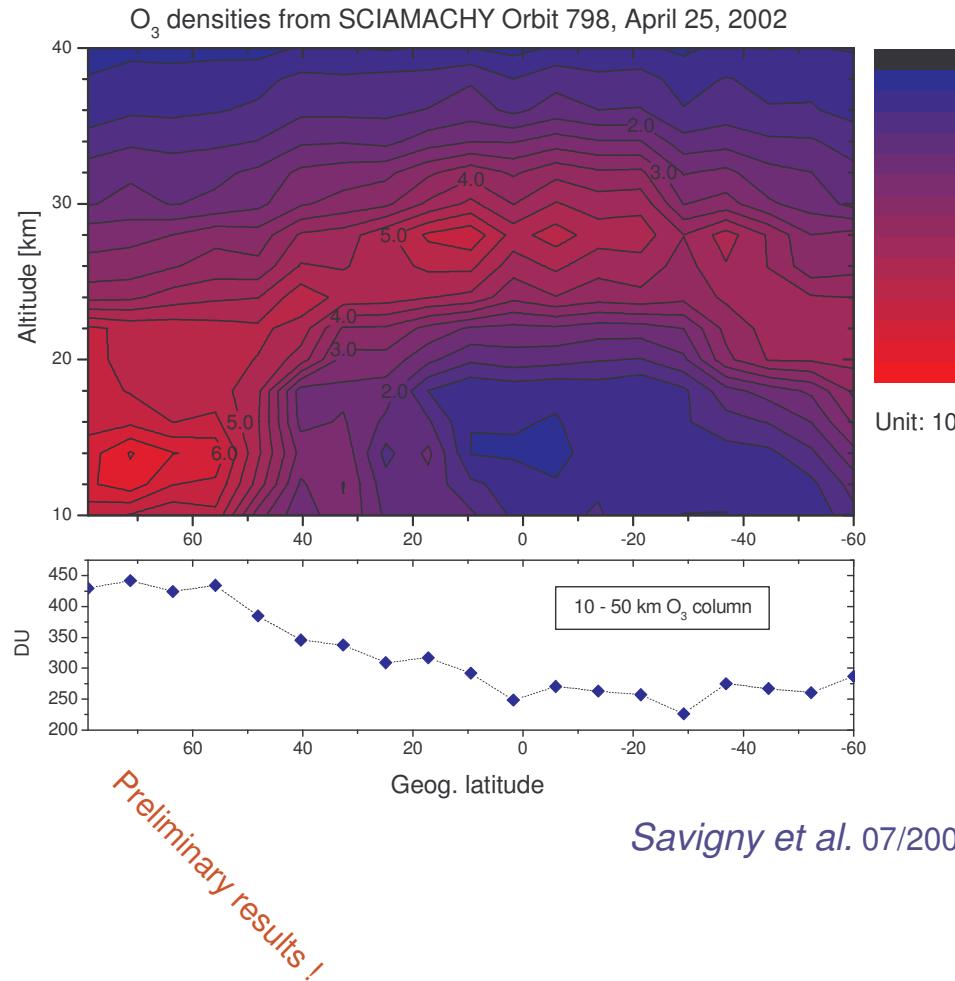
# Comparison of SCIAMACHY and POAM III ozone profiles



SCIAMACHY - POAM III coincidence on April 25, 2002

- □ SCIA, Rozanov Lat: 56°-59° N, Long: 238°-253°, 18:30 UTC
- ● SCIA, Savigny Lat: 56°-59° N, Long: 238°-253°, 18:30 UTC
- ● POAM, Lat: 62° N, Long: 253°, 2:50 UTC

$10 - 40$ km $O_3$ columns:
SCIAMACHY: 378 DU
POAM III: 384 DU

Total $O_3$ column:
GOME: 459 DU
TOMS: 456 DU

Altitude [km]

$O_3$ density [cm$^{-3}$]

Ozone fit at 20 km tangent height

Differential spectra

Residual

- Measured
- Simulated
- Residual

Wavelenght [nm]

Rozanov: Differential retrieval employing $O_3$ Chappuis bands
Savigny: 3 wavelength retrieval employing $O_3$ Chappuis bands

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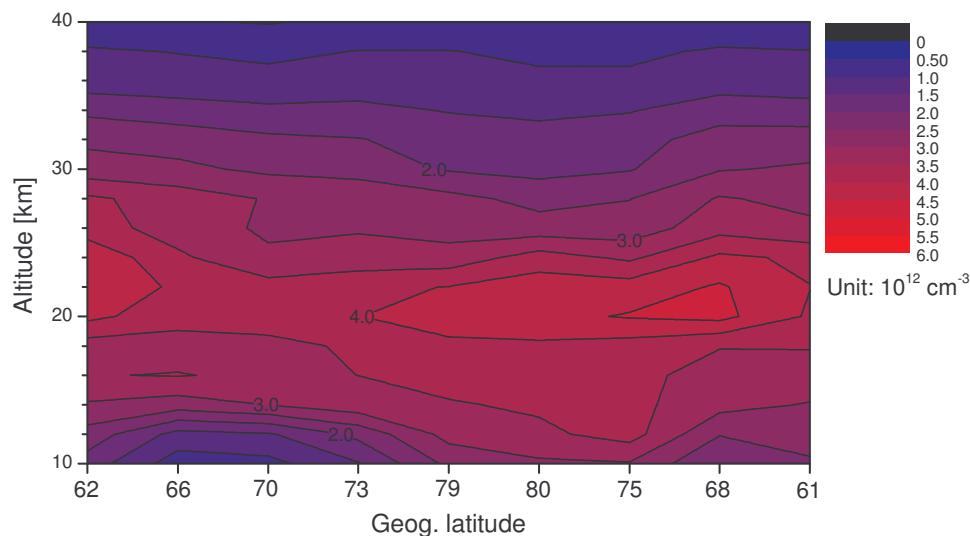
# SCIAMACHY and CTM Assimilation of GOME Data



O$_3$ densities from SCIAMACHY Orbit 798, April 25, 2002

Unit: $10^{12}$ cm$^{-3}$

10 - 50 km O$_3$ column

*Preliminary results !*

*Savigny et al.* 07/2002

CTM assimilation (NCAR-ROSE)

Courtesy Michael Bittner (DLR)

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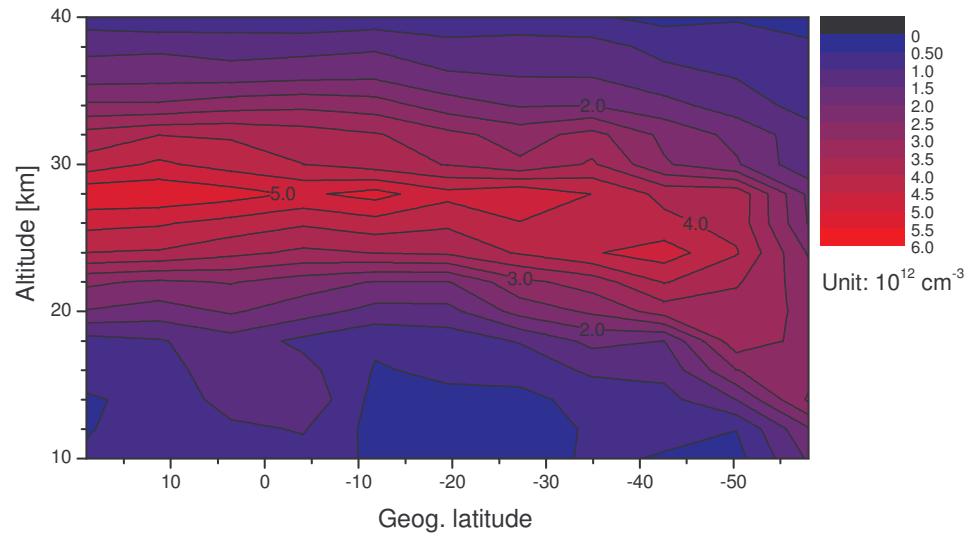
# Ozone cross sections for July 3, 2002, Orbit 1778

High latitude section

Low latitude section
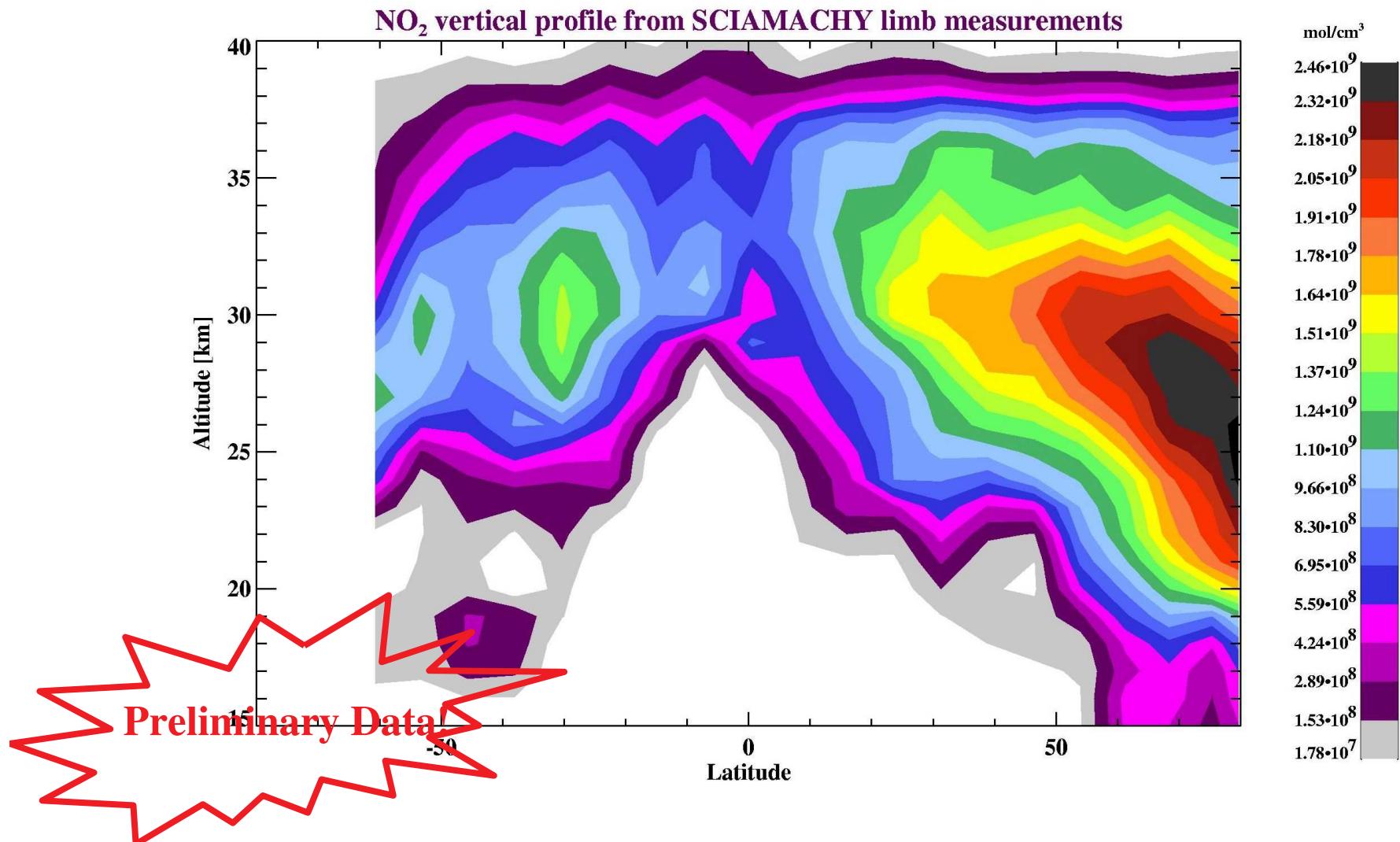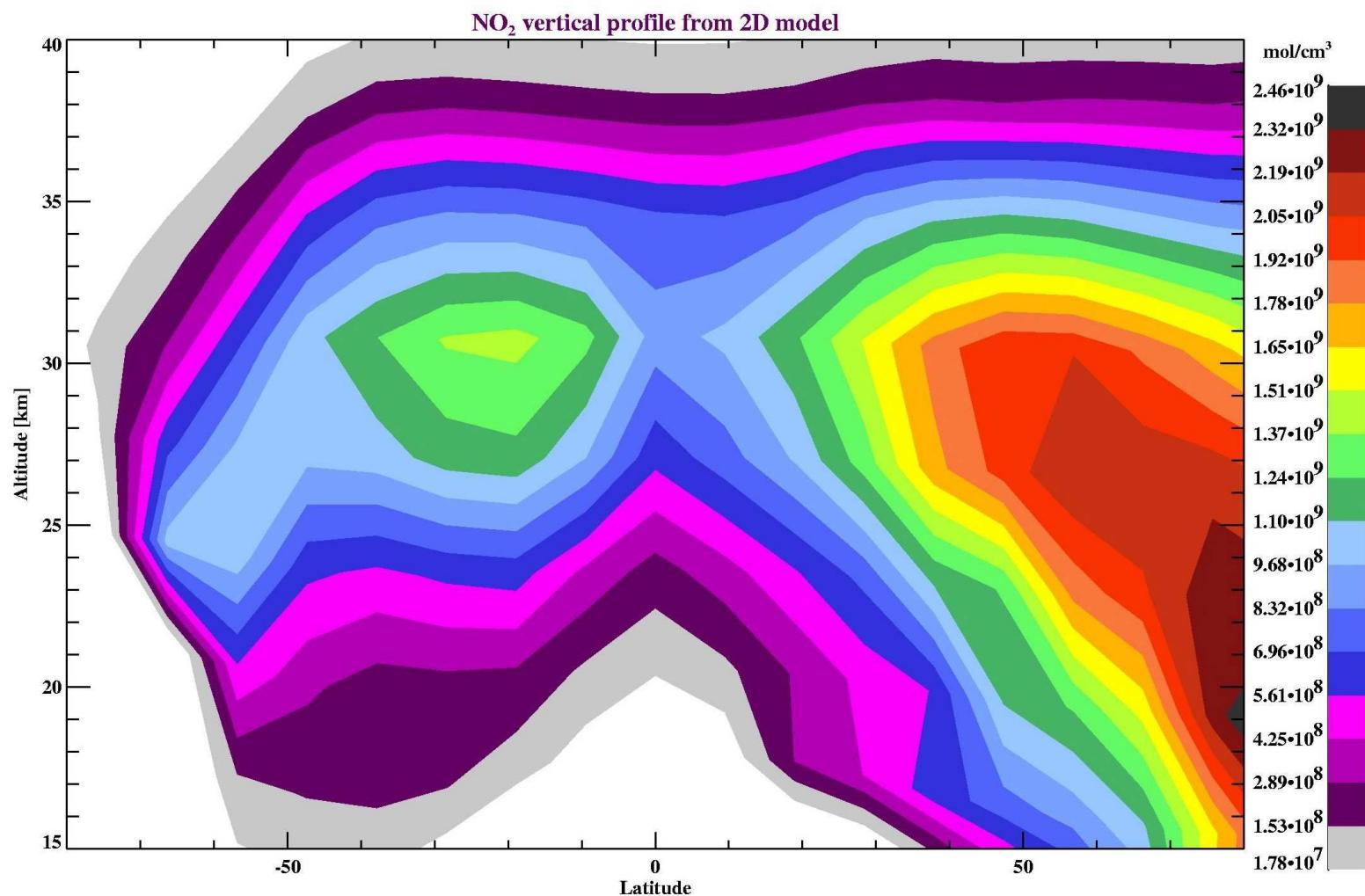
# SCIA Limb NO$_2$ (8.8.2002, Orbit 2302)



NO$_2$ vertical profile from SCIAMACHY limb measurements

Preliminary Data

# NO$_2$ 2D-Model



NO$_2$ vertical profile from 2D model

# Limb NO$_2$ Profile



NO$_2$ profile from SCIAMACHY limb measurements

SCIAMACHY

2 D climatological model

2 D model scaled to POAM mesurement:

SZA = 88 deg

SZA = 92 deg

SZA = 90 deg

?

Preliminary Data

Altitude [km]

NO$_2$ concentration mol/cm$^{-3}$

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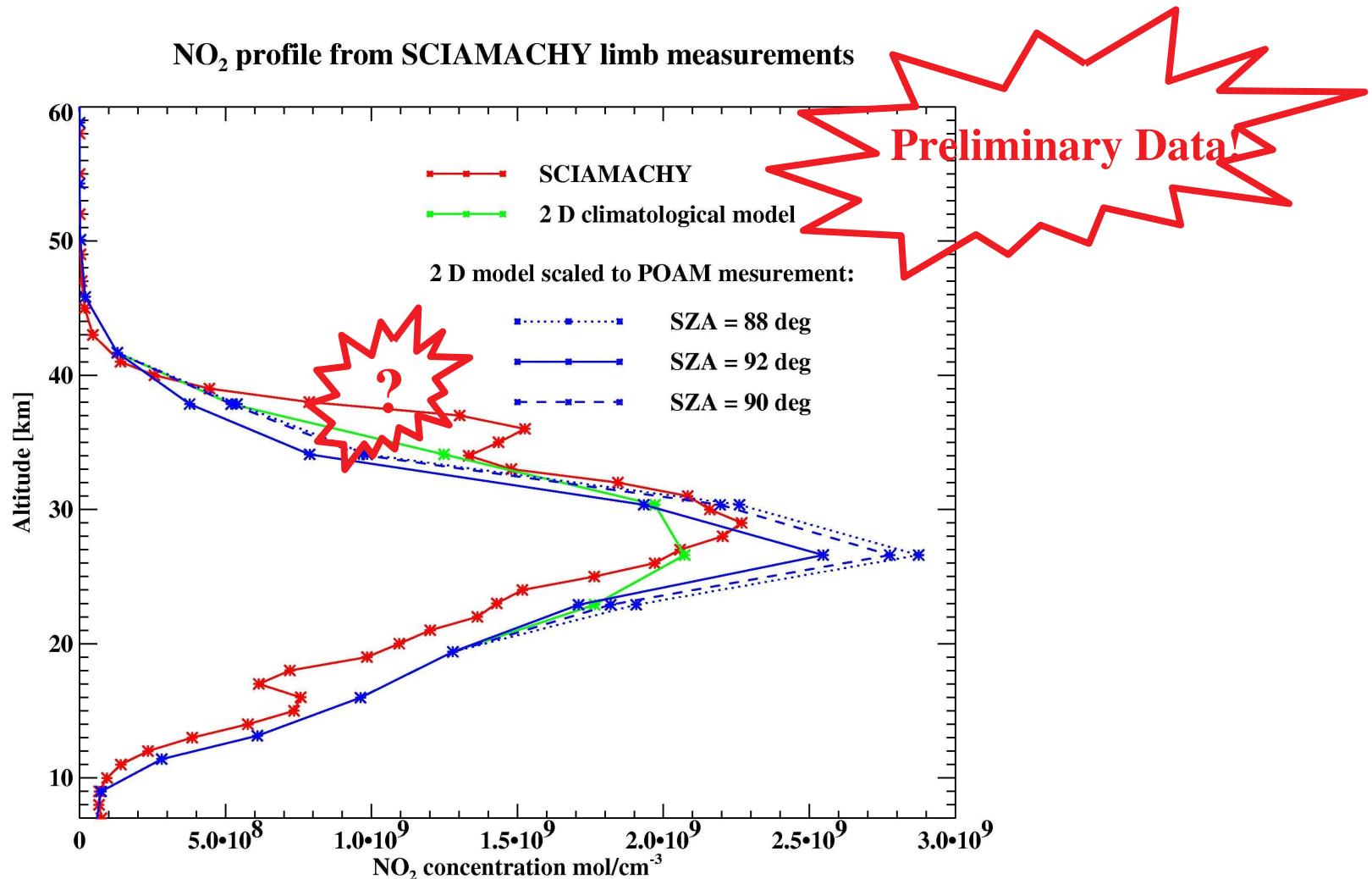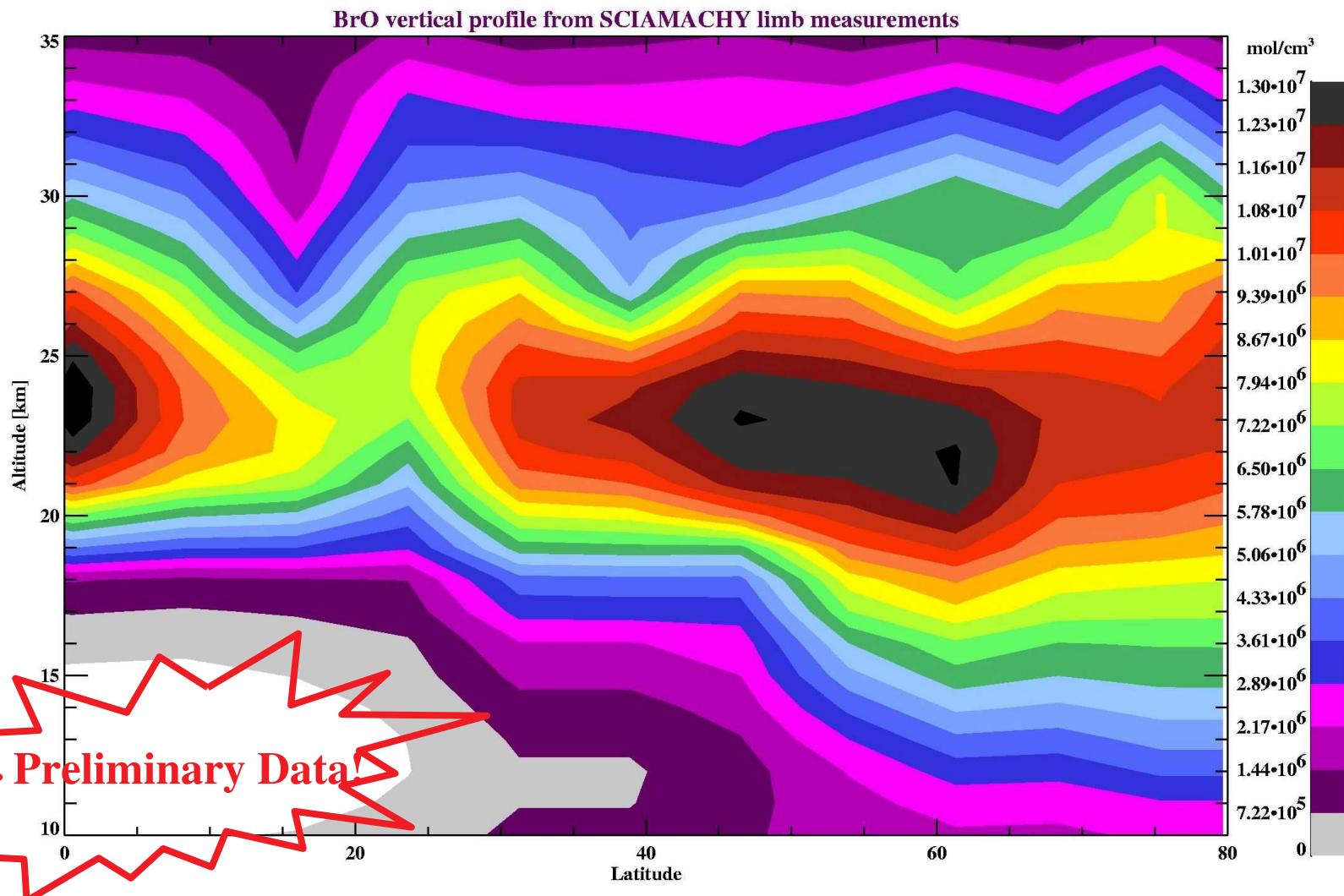
# SCIA Limb BrO (8.8.2002, Orbit 2302)
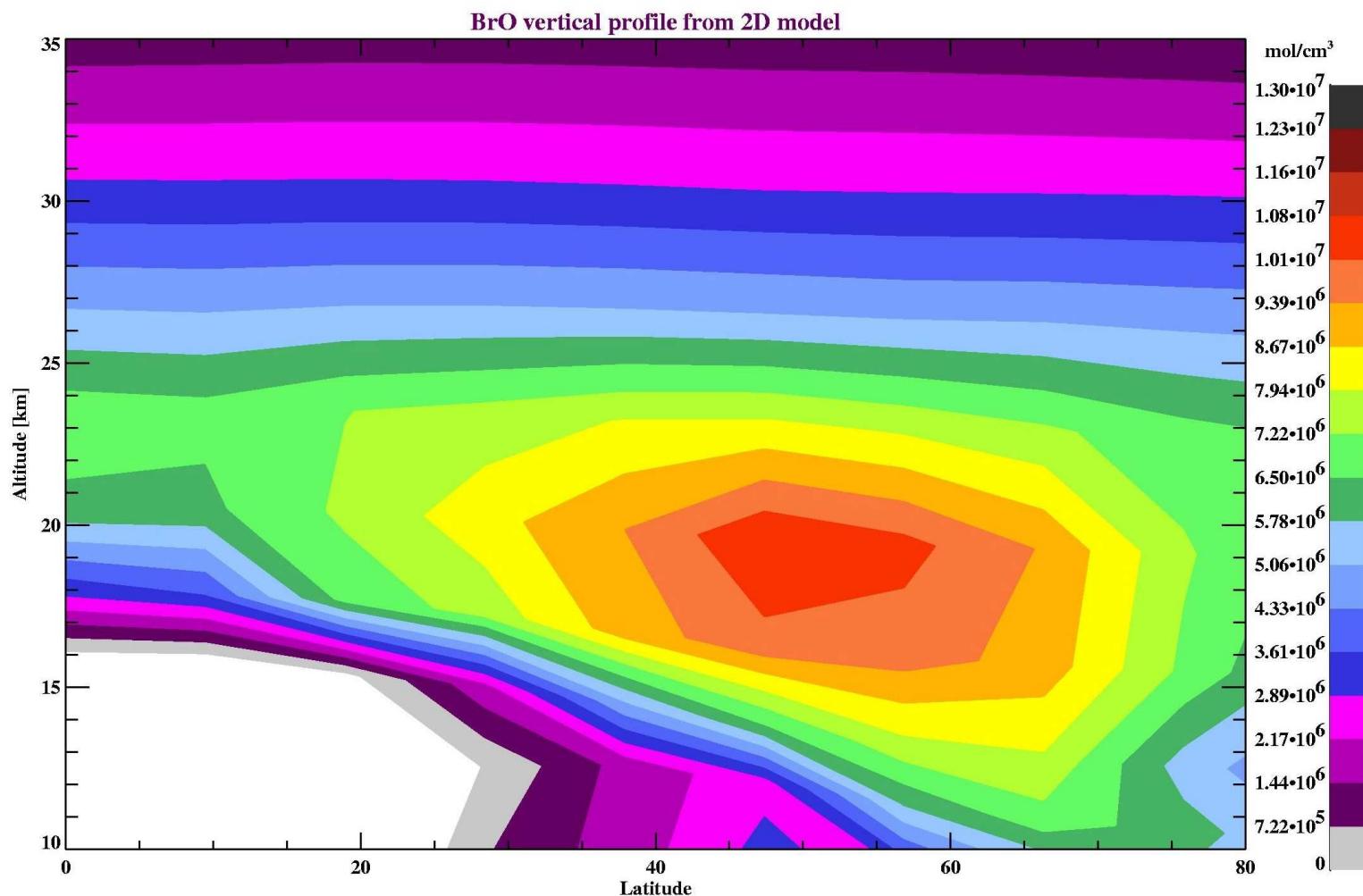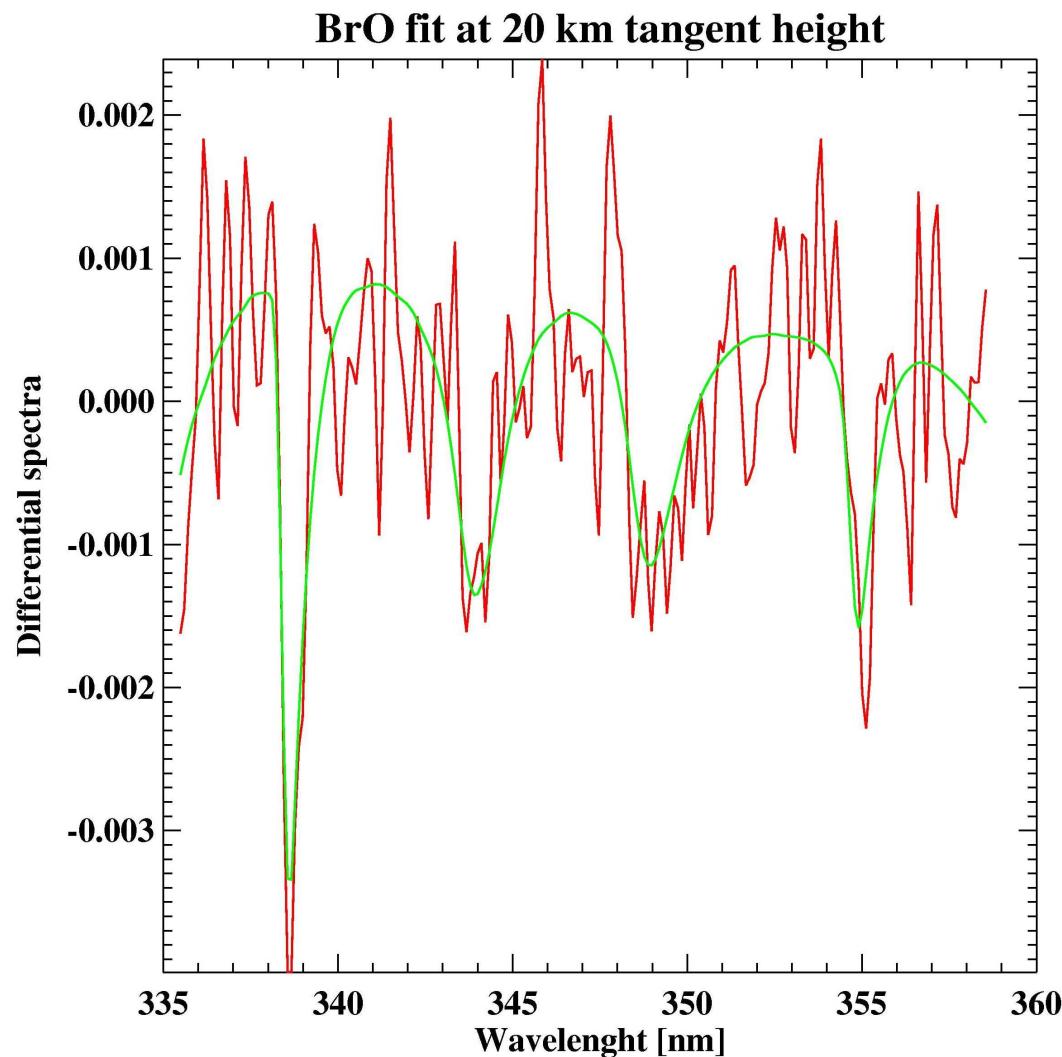


BrO vertical profile from SCIAMACHY limb measurements

# BrO 2D-Model



BrO vertical profile from 2D model

# Limb BrO Fit



BrO fit at 20 km tangent height
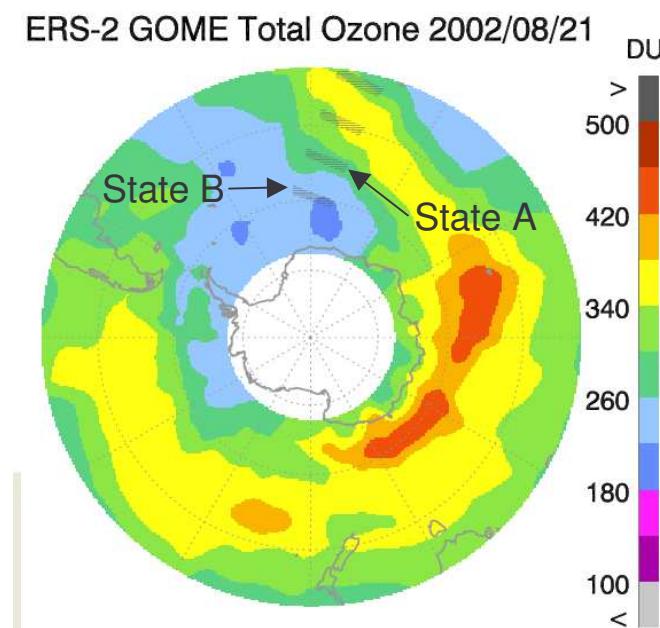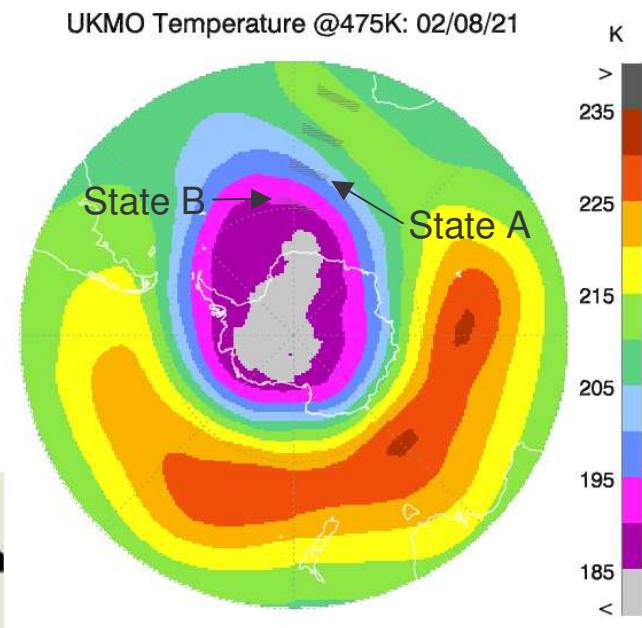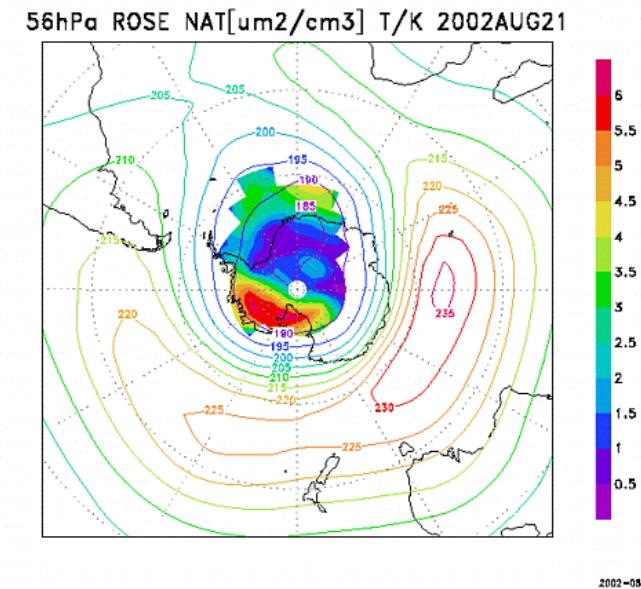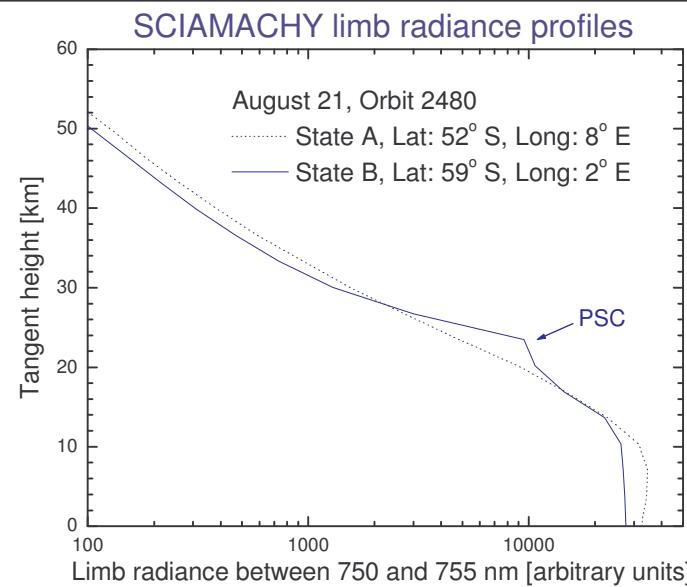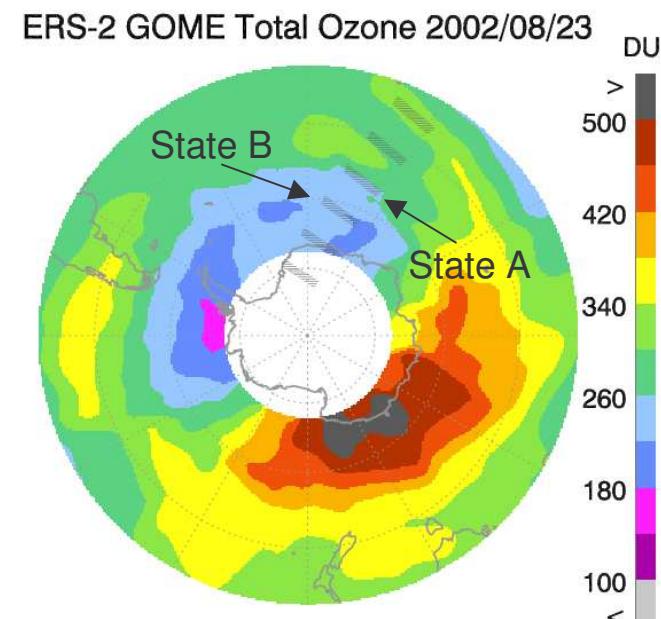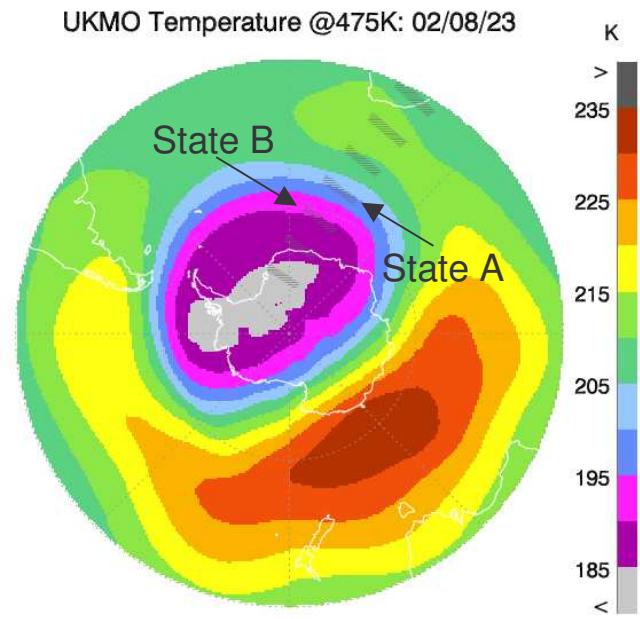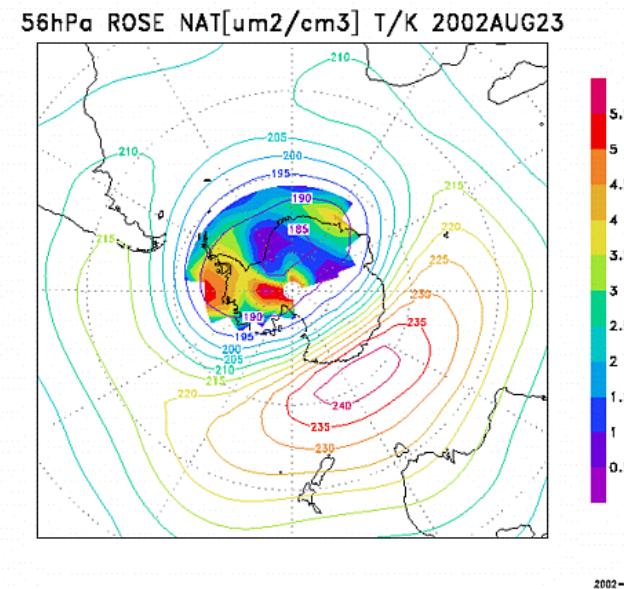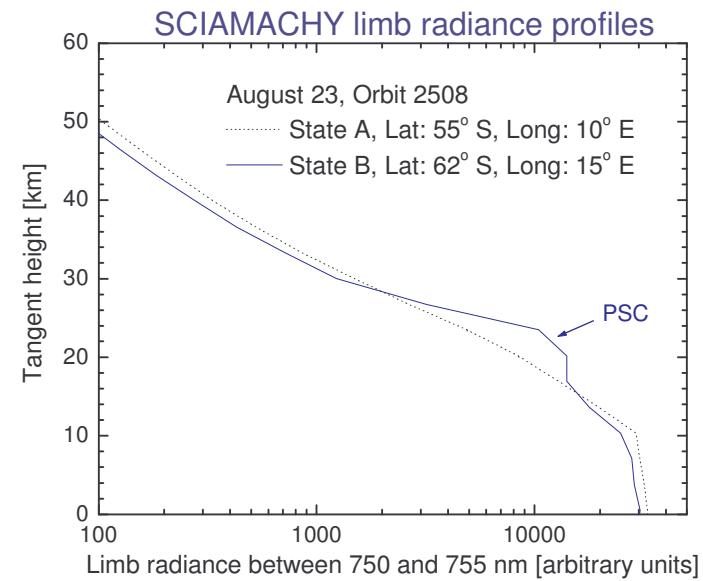
# First SCIAMACHY observations of PSCs:   Orbit 2480, 08/21/2002



SCIAMACHY limb radiance profiles

August 21, Orbit 2480
........ State A, Lat: 52° S, Long: 8° E
——— State B, Lat: 59° S, Long: 2° E

PSC

Tangent height [km]

Limb radiance between 750 and 755 nm [arbitrary units]



56hPa ROSE NAT[um2/cm3] T/K 2002AUG21



UKMO Temperature @475K: 02/08/21

State B    State A



ERS-2 GOME Total Ozone 2002/08/21

State B    State A
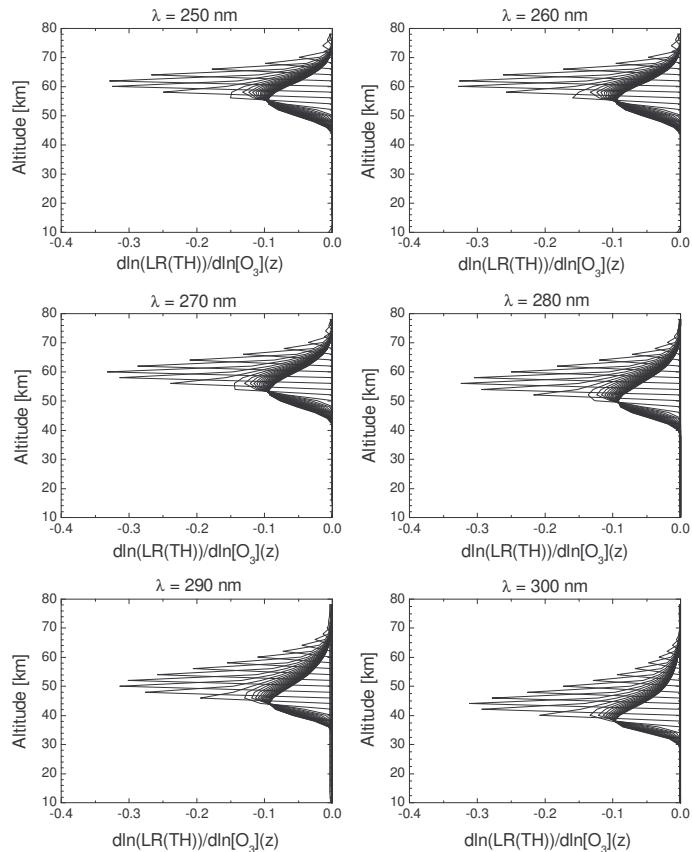
# First SCIAMACHY observations of PSCs:   Orbit 2508, 08/23/2002



SCIAMACHY limb radiance profiles

August 23, Orbit 2508
······ State A, Lat: 55° S, Long: 10° E
—— State B, Lat: 62° S, Long: 15° E

PSC

Tangent height [km]

Limb radiance between 750 and 755 nm [arbitrary units]



56hPa ROSE NAT[um2/cm3] T/K 2002AUG23



UKMO Temperature @475K: 02/08/23

State B
State A



ERS-2 GOME Total Ozone 2002/08/23

State B
State A
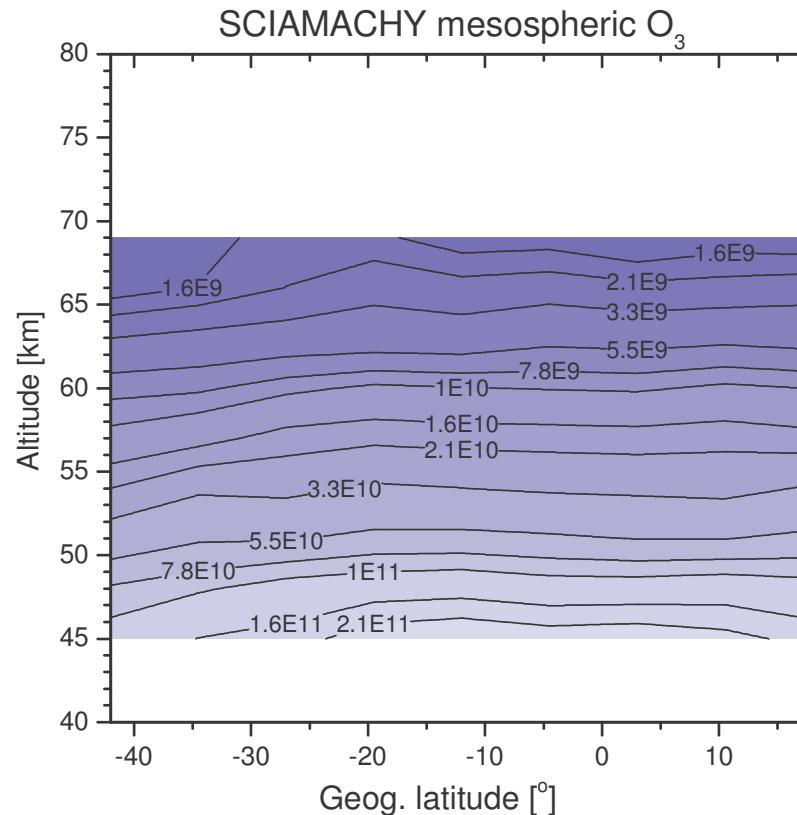
# Mesospheric $O_3$ retrieval in the Hartley bands

Radiance/[$O_3$] weighting functions



SCIAMACHY mesospheric $O_3$
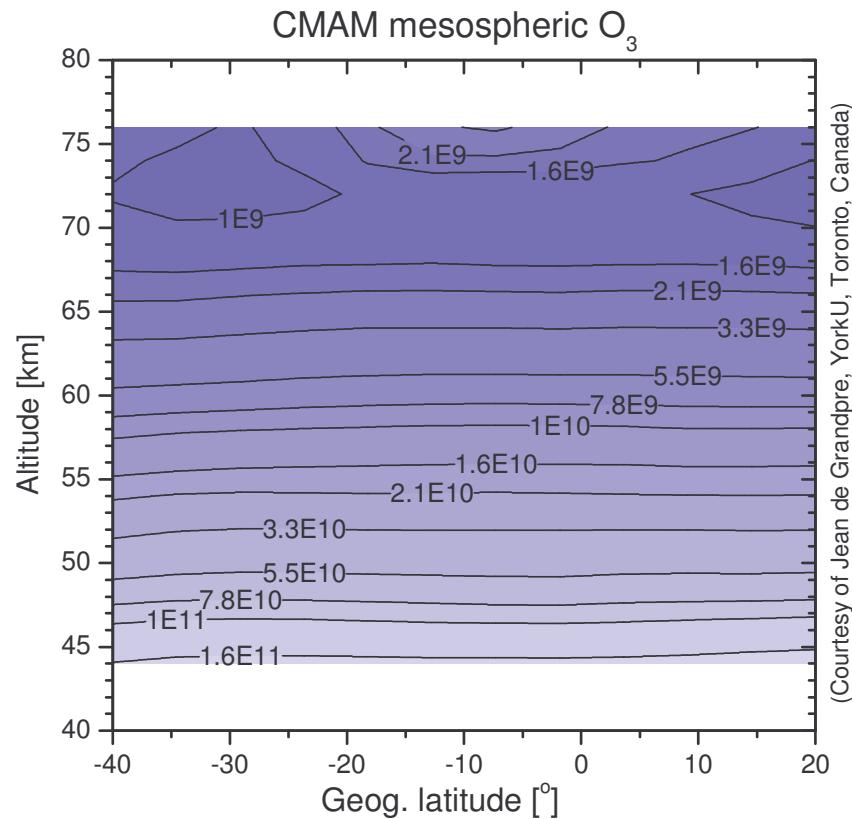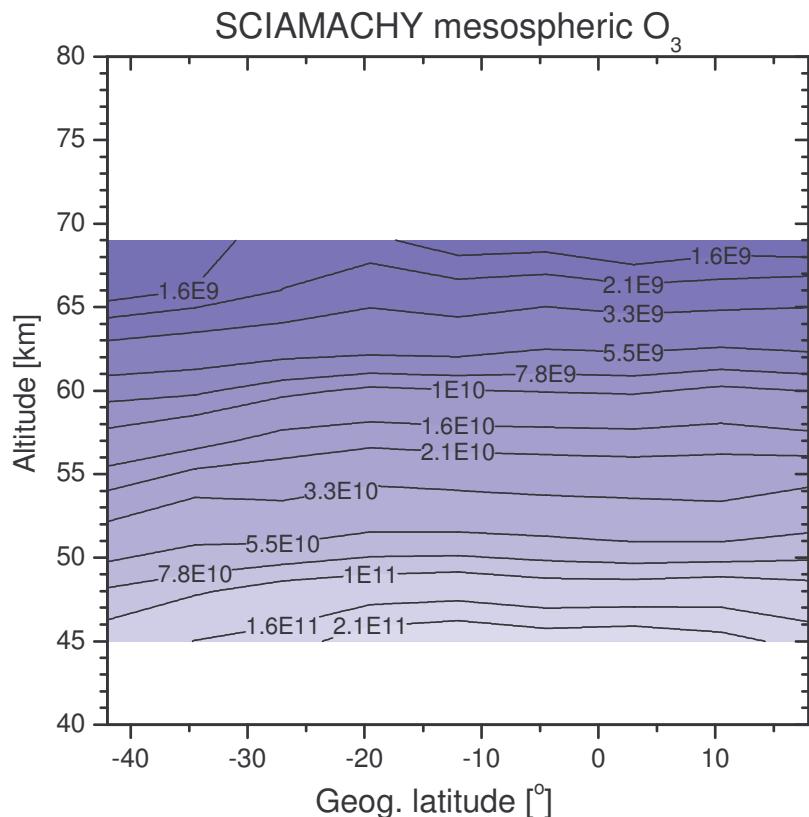
➡ Limb radiances in the Hartley bands
are sensitive to $O_3$ up to altitudes > 80 km

July 3, 2002, Orbit 1779

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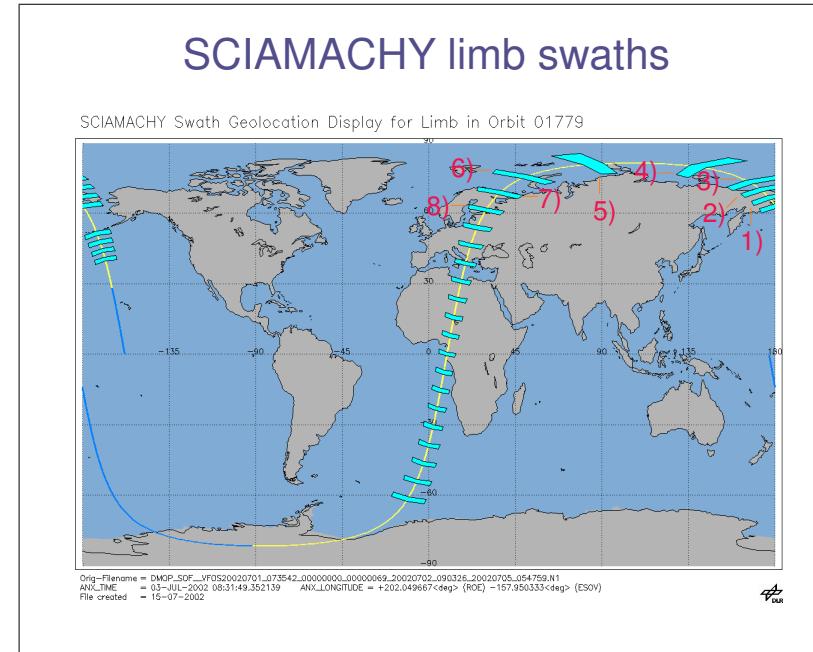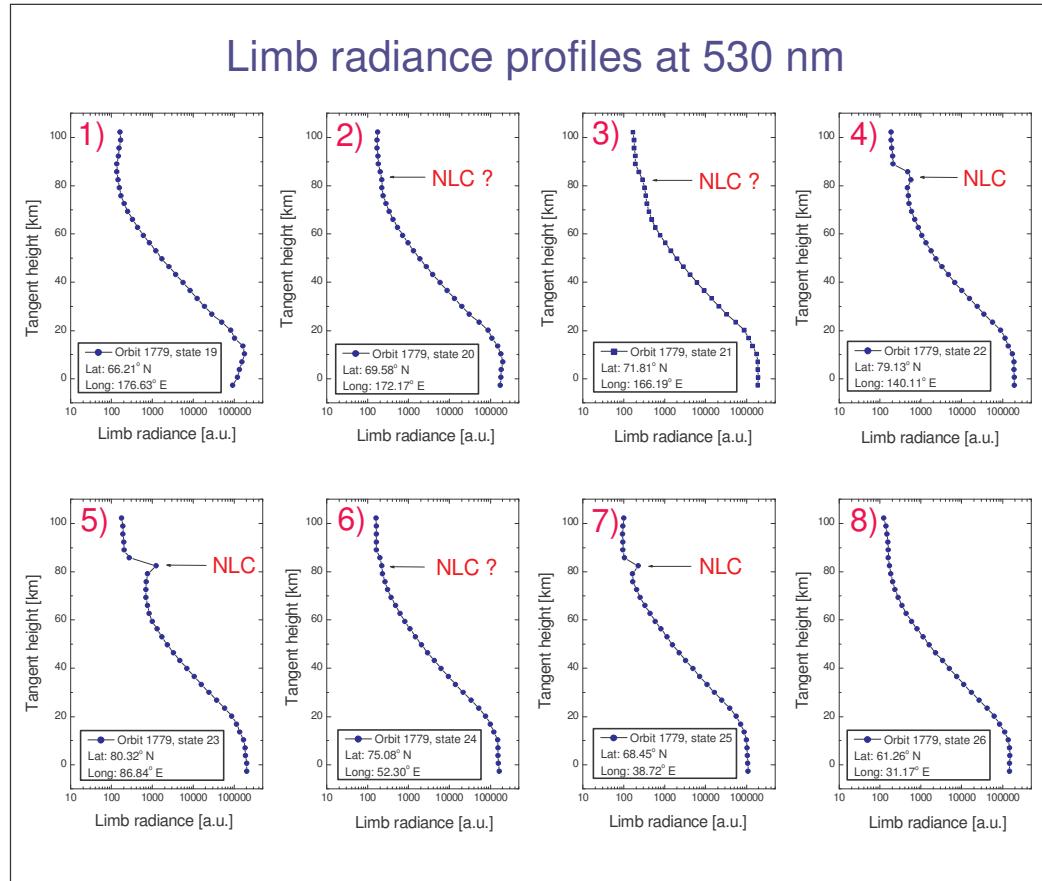
# Comparison with the Canadian Middle Atmosphere Model



July 3, 2002, Orbit 1779

# First SCIAMACHY observations of noctilucent clouds



Limb radiance profiles at 530 nm

SCIAMACHY limb swaths
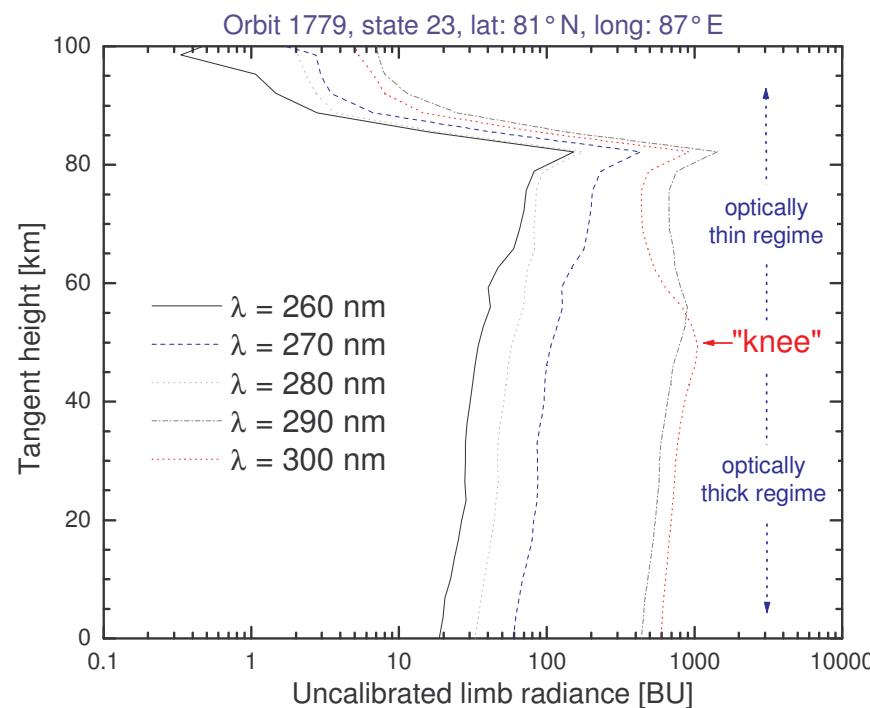
Orbit 1779, July 3, 2002
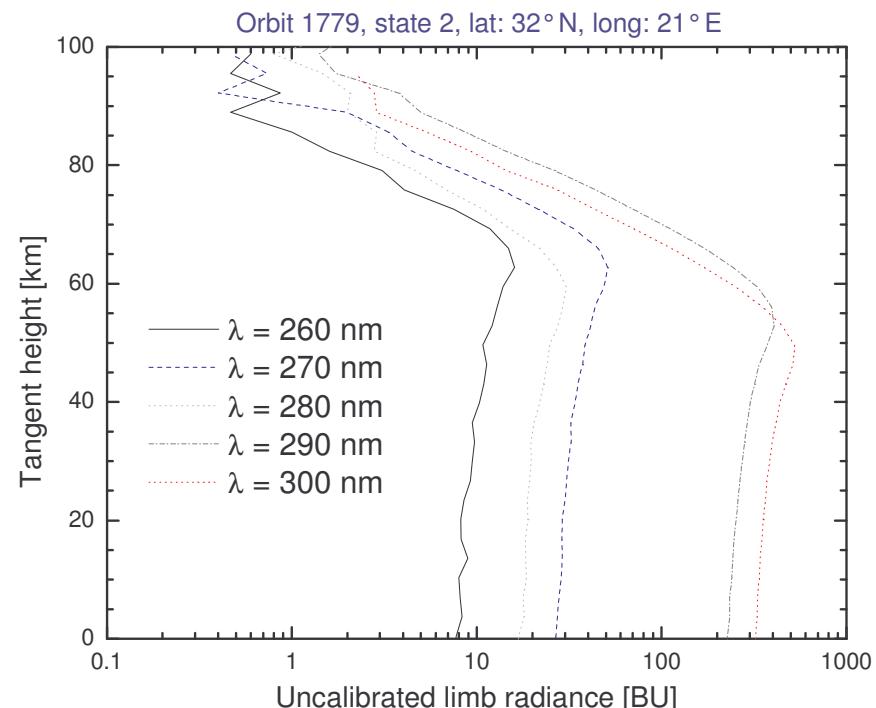
# First SCIAMACHY observations of noctilucent clouds

## UV limb radiance profiles



**with NLC** — Orbit 1779, state 23, lat: 81° N, long: 87° E
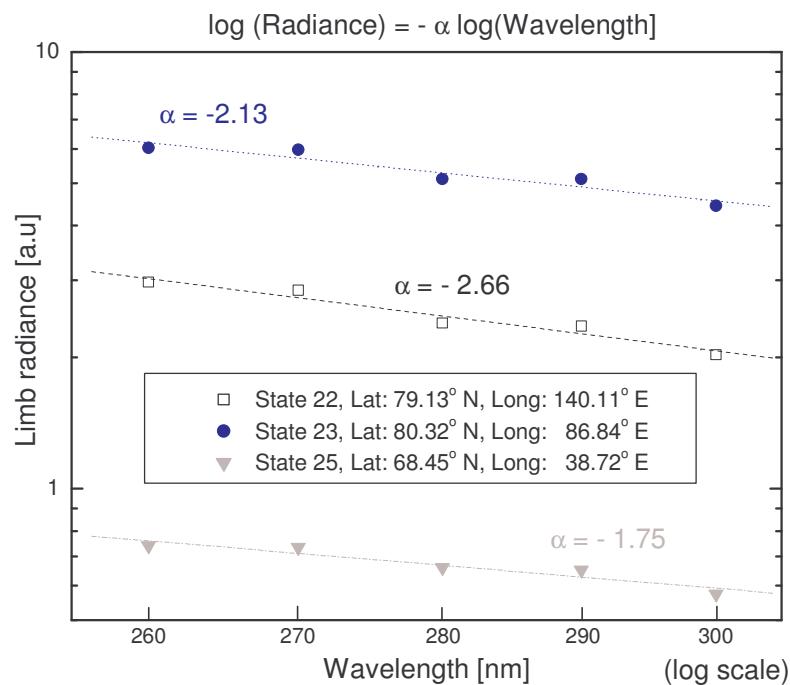
**without NLC** — Orbit 1779, state 2, lat: 32° N, long: 21° E
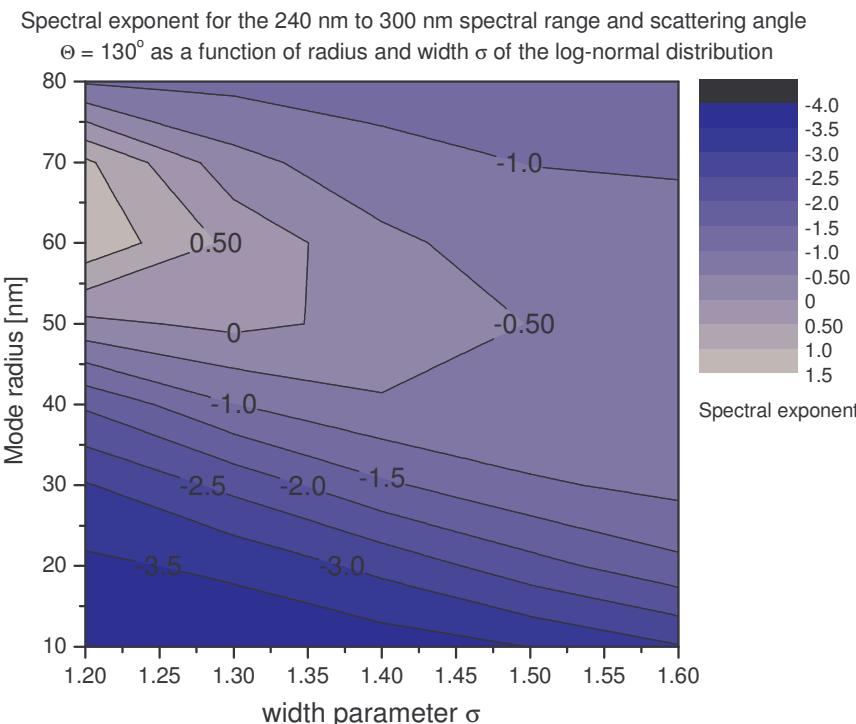
# Estimation of NLC particle radii ??

## Observed Spectral exponent of the NLC spectrum

log (Radiance) = - α log(Wavelength]



## Modelled spectral exponents

Spectral exponent for the 240 nm to 300 nm spectral range and scattering angle
$\Theta = 130°$ as a function of radius and width $\sigma$ of the log-normal distribution



**Ambiguity**: spectral exponent not monotonously increasing with increasing radius

→ Use several and significantly different wavelengths to determine $r_m$ and $\sigma$ [*von Cossart et al*, 1999].
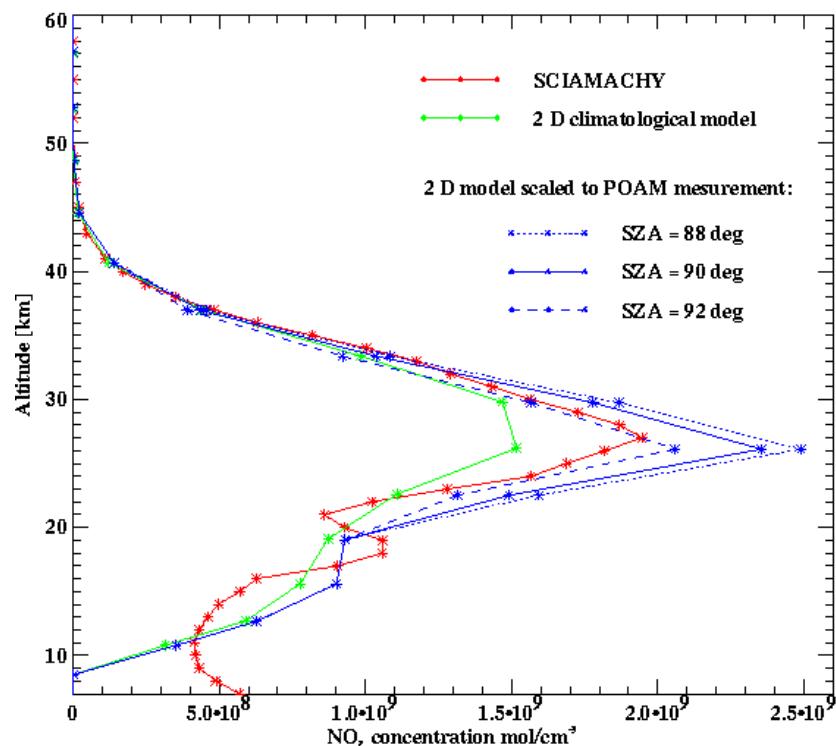
**Model assumptions**:
- Mie theory
- Refractive index of ice
- Log-normal distribution

# Conclusion

- **Successful retrievals of**
  - stratospheric O3 profiles
  - stratospheric NO2 profiles
  - mesospheric O3

- **Detection of**
  - Polar stratospheric clouds
  - Noctilucent clouds/Polar mesospheric clouds

- **Estimation of NLC particle sizes**

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# NO$_2$ retrieval from SCIAMACHY limb observations
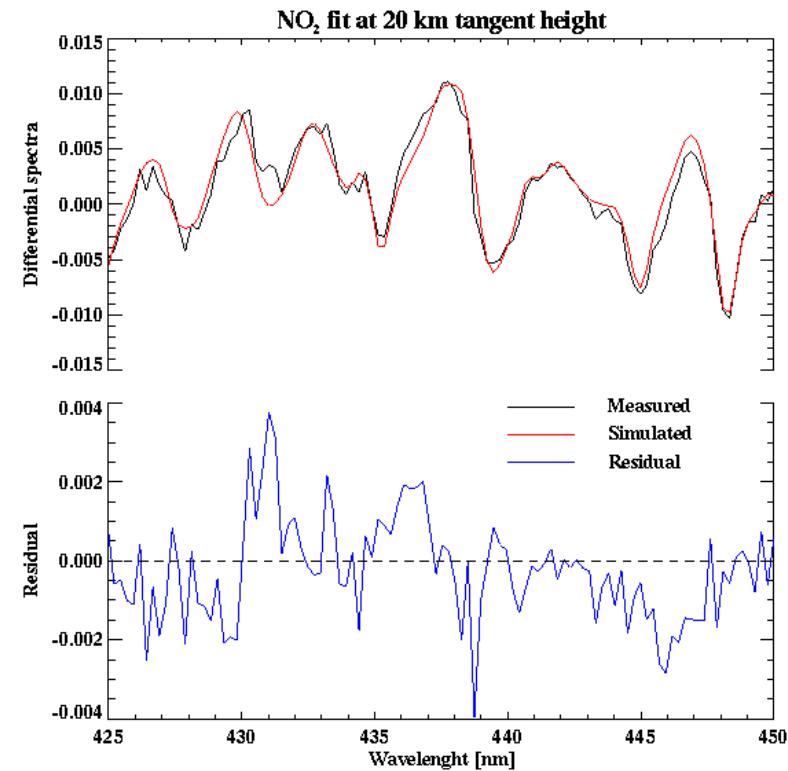


SCIAMACHY: 58°N, 110°W, SZA = 68 deg
POAM:          62°N, 110°W
Green curve: simulation with 2 D Model at 58°N, 110°W, SZA = 68 deg
Blue curves:  simulation with 2 D Model at corresponding SZA.
NO$_x$ was scaled to the POAM measurement and used as input to simulate
the diurnal variation of the NO$_2$ vertical profile backward to SZA = 68 deg.
(All model runs by *Miriam von König*)
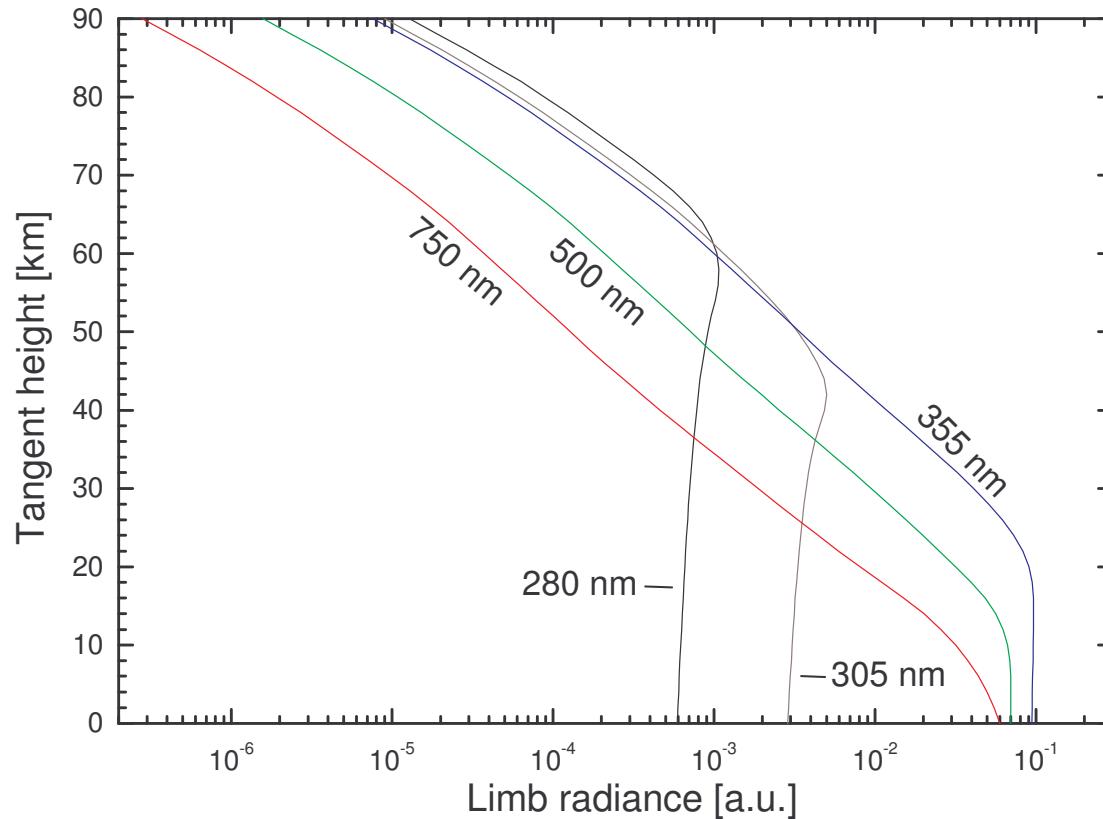
# Modelled limb radiance profiles



- The detected limb radiance corresponds to the solar radiation that is scattered along the instrument line of sight and transmitted to the observer