Particle size distribution of the stratospheric aerosol from SCIAMACHY: sensitivity studies and first results

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1. SCIAMACHY instrument
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1. SCI AMACHY instrument
SCI AMACHY ON ENVI SAT

SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY)

Operating time: March 2002 – April 2012
Orbit: sun-synchronous, ~800 km altitude
Spectral range: 214 – 2386 nm
Spectral resolution: 0.22 – 1.48 nm
Vertical range (limb): -3 – 100 km
Vertical sampling/field of view: 3.3/2.5 km
Horizontal swath/resolution: 960/240 km

Measurement modes:
1. Nadir
2. **Limb**
3. Occultation
2. Retrieval information
• Sun-normalized radiances in the altitude range from 18 to 35 km
• Wavelengths (±2 nm): 470, 750, 807, 870, 1090, 1236, 1295, 1557
• Low sensitivity to aerosols: 375 nm → not used
• Lower signal-to-noise ratio (channel 6+): 1592 nm, 1625 nm and 1674 nm
• Radiative transfer model with the retrieval code (OE type) SCIATRAN-3.7
• Surface albedo is included in the retrieval

Difference between the logarithms of the radiance without and with absorption by gaseous species (optical depth). Green - selected wavelengths, gray - channel boundaries.
**Aerosol characteristics:**

Particle size distribution (PSD) Assumed as lognormal

\[ n(r) = \frac{N}{r(2\pi)^{\frac{1}{2}} \ln(\sigma)} \exp\left(\frac{-\ln\left(\frac{r}{r_0}\right)^2}{2(\ln(\sigma))^2}\right) \]

\( N \) – particle number density

\( r_0 \) – **MEDIAN** radius

\( \sigma \) – distribution width (rel)

 Retrieval

Mode radius: \( R_{mod} = \frac{r_0}{e^{\sigma^2}} \)

Distr. width (abs): \( R_{mod} \times \sigma \)
MODELED INTENSITIES WITH DIFFERENT PSD
MODELED INTENSITIES WITH DIFFERENT PSD

-4.5
-5.0
-5.5
-6.0
-6.5
-7.0
-7.5
-8.0
-8.5
-9.0

Wavelength, nm

ln(sun-normalized radiance)

R_{mod} = 0.08, \sigma = 1.37, 1^\circ N
R_{mod} = 0.05, \sigma = 1.37, 1^\circ N
R_{mod} = 0.06, \sigma = 1.37, 1^\circ N
R_{mod} = 0.07, \sigma = 1.37, 1^\circ N
R_{mod} = 0.09, \sigma = 1.37, 1^\circ N
R_{mod} = 0.10, \sigma = 1.37, 1^\circ N
R_{mod} = 0.11, \sigma = 1.37, 1^\circ N
R_{mod} = 0.12, \sigma = 1.37, 1^\circ N
R_{mod} = 0.13, \sigma = 1.37, 1^\circ N
R_{mod} = 0.14, \sigma = 1.37, 1^\circ N
R_{mod} = 0.15, \sigma = 1.37, 1^\circ N
R_{mod} = 0.08, \sigma = 1.37, 1.2^\circ N
R_{mod} = 0.08, \sigma = 1.37, 1.4^\circ N
R_{mod} = 0.08, \sigma = 1.37, 1.6^\circ N
R_{mod} = 0.08, \sigma = 1.37, 1.8^\circ N
R_{mod} = 0.08, \sigma = 1.37, 2.0^\circ N
MODELED INTENSITIES WITH DIFFERENT PSD

\[ \ln(\text{sunnormalized radiancy}) \]

Wavelength, nm

700 800 900 1000 1100 1200 1300 1400 1500 1600
Correlation of the weighting functions → retrieval of mode radius and distribution width
3. Synthetic retrieval
SYNTHETIC RETRIEVALS

- Synthetic retrievals of the background conditions for tropical geometry
- Perturbation of apriori radius and sigma (factor 1.4)
- Perturbation of apriori radius, sigma and number density (factor 1.4)
- Error about 20 % for radius and about 10 % for sigma
4. Real data retrieval
RETRIEVAL RESULTS: TIME SERIES (TROPICS)

Cloud free measurements
±20° latitude
9732 cases

- 18.0 km
- 21.3 km
- 24.6 km

R_{mod}, \mu m

width, \mu m

ANOMALIES: MODE RADIUS

19.0 km

21.7 km

25.0 km

28.3 km

[Graphs showing data for different distances and locations]
ANOMALIES: DISTRIBUTION WIDTH

19.0 km

21.7 km

25.0 km

28.3 km

dist.width anomaly, µm


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RETRIEVAL RESULTS: TIME SERIES (TROPICS)

18 km

22 km

25 km

Apr 06
Jul 06
Oct 06
Jan 07
Apr 07
Jul 07
Oct 07

Tavurvur
5. SAGE II comparison
SAGE II COMPARISON

- August 2002 – August 2005
- ±5° latitude, ±10° longitude, ±24 hours (38 cases)
- Effective radii comparison

\[ r_{eff} = r_0 \exp\left(5 \ln(\sigma)^2 / 2\right) \]
6. Conclusions
CONCLUSIONS

• *Retrieval of* aerosol particle size distribution parameters from SCIAMACHY Limb data *was performed for the first time*
• For now on it is possible to *retrieve* just *mode radius* and *distribution width*
• *Mode radius* and *distribution width* retrieval show good results for tropics
• *Retrieval of* the aerosol particle size distribution parameters *was done for the whole* SCIAMACHY operating *period*
• Analysis of the time series showed a *significant change* of the *mode radius* and *distribution width* after the volcanic eruptions, and tape recorder for both of them
• *Comparison* of the retrieved effective radius *with SAGE II* in the tropics showed *promising* results

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