

# 7th Atmospheric Limb Conference

 LIMB-13



**This presentation participates  
in the student award contest**

# Decadal changes in O<sub>3</sub> and NO<sub>2</sub> seen by SCIAMACHY limb

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O<sub>3</sub> and NO<sub>2</sub> measured by SCIAMACHY limb

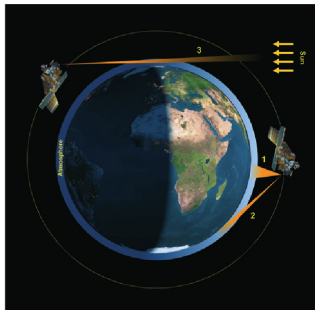
Linear changes/Trends of limb O<sub>3</sub> and NO<sub>2</sub> seen by SCIAMACHY after 2002

Comparison with vertically resolved O<sub>3</sub> linear changes/trends derived from other measurements

Comparison between SCIAMACHY integrated limb and nadir O<sub>3</sub> and NO<sub>2</sub>

Conclusions

# SCIAMACHY measurement geometries



## SCIAMACHY

- ▶ hosted by ENVISAT (2002-12)
- ▶ 3 measurement geometries:  
limb, nadir, and occultation

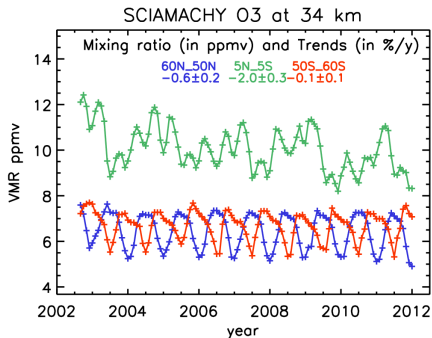
## SCIAMACHY limb

- ▶ global coverage within 6 days at the equator
- ▶ line of sight scans the horizon in vertical steps of 3.3 km
- ▶ O<sub>3</sub> and NO<sub>2</sub> retrieved in 1 km steps

## Considered in the following:

- ▶ O<sub>3</sub> from 20-50 km
- ▶ NO<sub>2</sub> from 20-40 km

# O<sub>3</sub> time series from SCIAMACHY limb



## Easily identifiable periodic features

- ▶ annual cycle in the midlatitudes with maximum in summer
- ▶ QBO pattern in the tropics overlaid by the semi-annual oscillation



## Concept of linear changes/trends

- ▶ decadal changes of O<sub>3</sub> appropriately modelled as linear
- ▶ linear changes/trends are seen by SCIAMACHY within the period 2002-2012

## Multivariate linear regression

- ▶ harmonic functions approximate (semi-)annual oscillation (6+12 months among the periods)
- ▶ Singapore winds as QBO proxy (10 + 30 hPa) and Mg II index as solar cycle proxy
- ▶ linear part provides the trend

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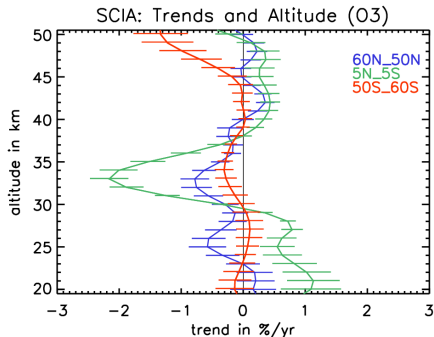
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# Ozone linear changes/trends from SCIAMACHY limb



## Features, which stand out and require discussion

- ▶ dipole structure of the tropical trend profile (15-40 km)
  - positive trends between 20-30 km
  - negative trends between 30-35 km
- ▶ moderate positive trends at 40-45 km



# Explanation of vertical profile linear changes/trends in O<sub>3</sub> from SCIAMACHY limb

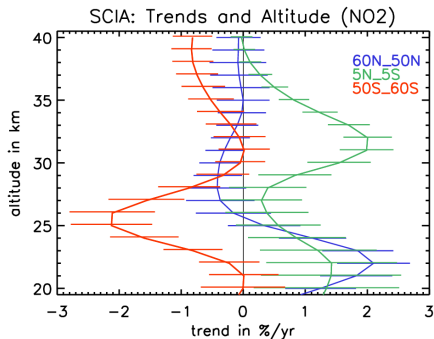
## Halogen chemistry

- ▶ upper stratosphere: moderate positive O<sub>3</sub> trends expected in response halogens decreasing slowly

## NO<sub>x</sub> chemistry

- ▶ in the middle tropics, NO<sub>x</sub> may play an important role: positive NO<sub>2</sub> linear changes/trends of similar magnitude to that required
- ▶ NO<sub>x</sub> chemistry may also explain positive O<sub>3</sub> trends in the lower tropics: buffering effects lead to a net increase of O<sub>3</sub>

# NO<sub>2</sub> linear changes/trends seen by SCIAMACHY limb



- ▶ positive linear changes/trends up to +2 % per year in the tropical 30-35 km range

O<sub>3</sub> and NO<sub>2</sub> measured by SCIAMACHY limb

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# Comparison instruments: other limb sounders and ozonesondes

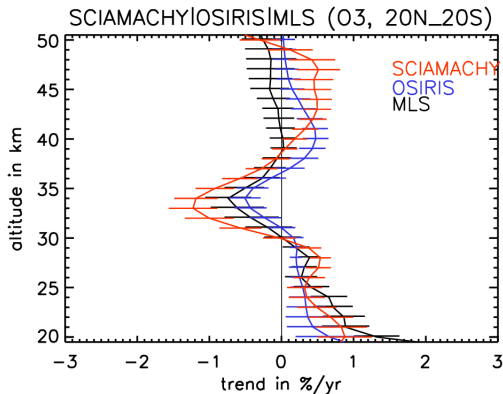
## Odin\Osiris

- ▶ limb measurements in the 200-800 nm range
- ▶ started 2001
- ▶ near terminator orbit

## Aura-MLS

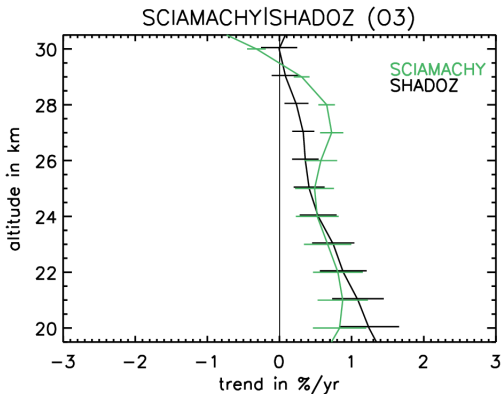
- ▶ limb measurements in the microwave spectral range
- ▶ started 08/2004

# Comparison of the linear changes/trends in vertical $O_3$ profiles from 3 limb datasets



- ▶ latitude zone: 20N-20S
- ▶ time span: 08/2004-12/2011

# Comparison of the linear changes/trends in limb O<sub>3</sub> profiles to ozonesondes



- ▶ SCIAMACHY: 5N-5S
- ▶ SHADOZ: Ascension, Kuala Lumpur, Nairobi, Natal, and Paramaribo (averaged)

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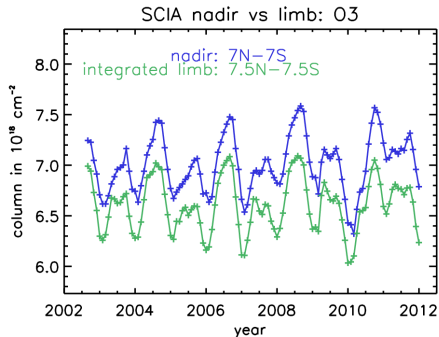
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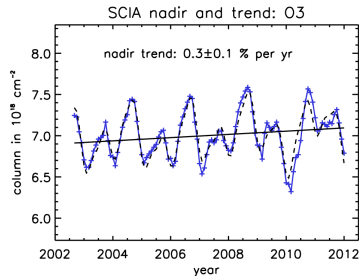
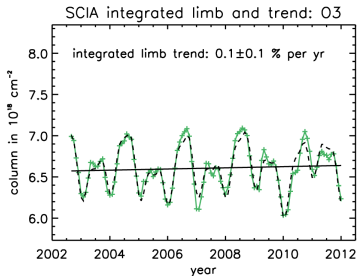


# Comparison of SCIAMACHY integrated limb and nadir $O_3$



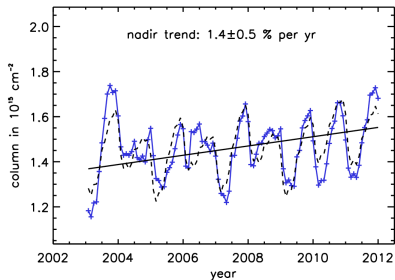
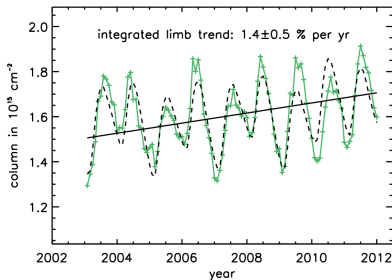
- ▶ time series of integrated limb and nadir  $O_3$
- ▶ large parts of column  $O_3$  are stratospheric

# Comparison of SCIAMACHY integrated limb and nadir $O_3$



- ▶ integrated limb  $O_3$  show consistently near zero trends as net effect of vertically resolved trends
- ▶ nadir total  $O_3$  agrees within uncertainties

# Comparison of SCIAMACHY integrated limb and nadir $\text{NO}_2$



- ▶ comparison of integrated limb and total  $\text{NO}_2$  both from SCIAMACHY
- ▶ significant positive trend is shown consistently



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- ▶ Using our analysis approach in the tropical lower and middle stratosphere,  $O_3$  linear changes/trends after 2002 are dipole-shaped: positive in LS and negative MS
- ▶ in the middle stratosphere, positive linear changes of  $NO_2$  are consistent
- ▶ good agreement of linear changes/trends between SCIAMACHY limb and other measurements

## Outlook

- ▶ Gebhardt et al., ACPD
- ▶ reproduction and attribution of the O<sub>3</sub> and NO<sub>2</sub> linear changes/trends by CTMs

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