Global Atomic Oxygen Abundance in the Upper Mesosphere and Lower Thermosphere as Measured by SCIAMACHY

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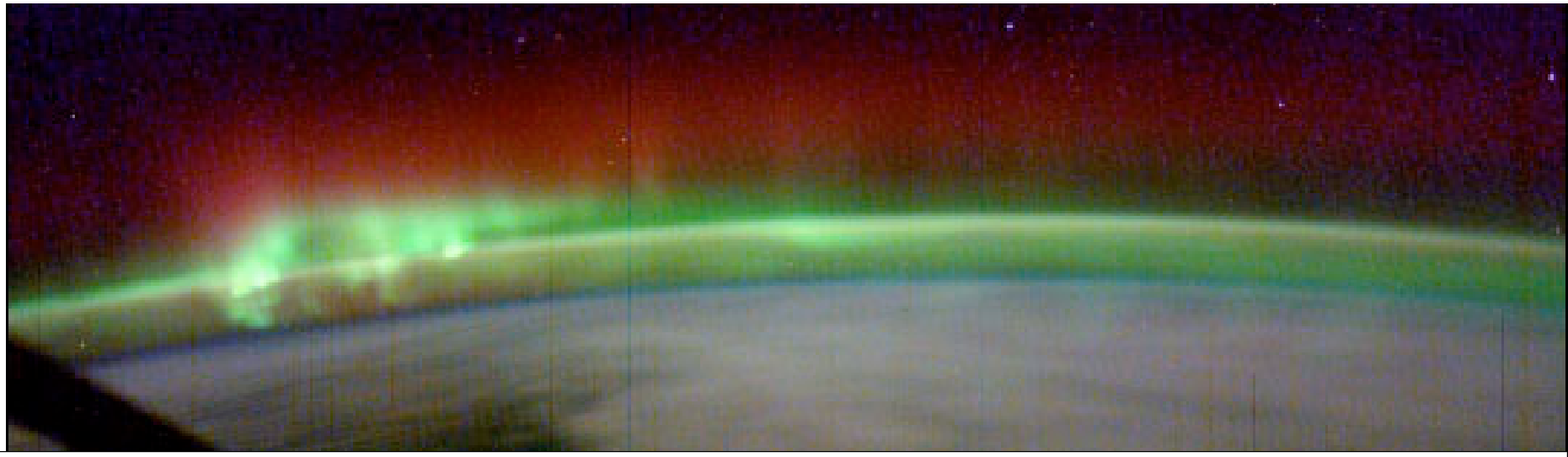
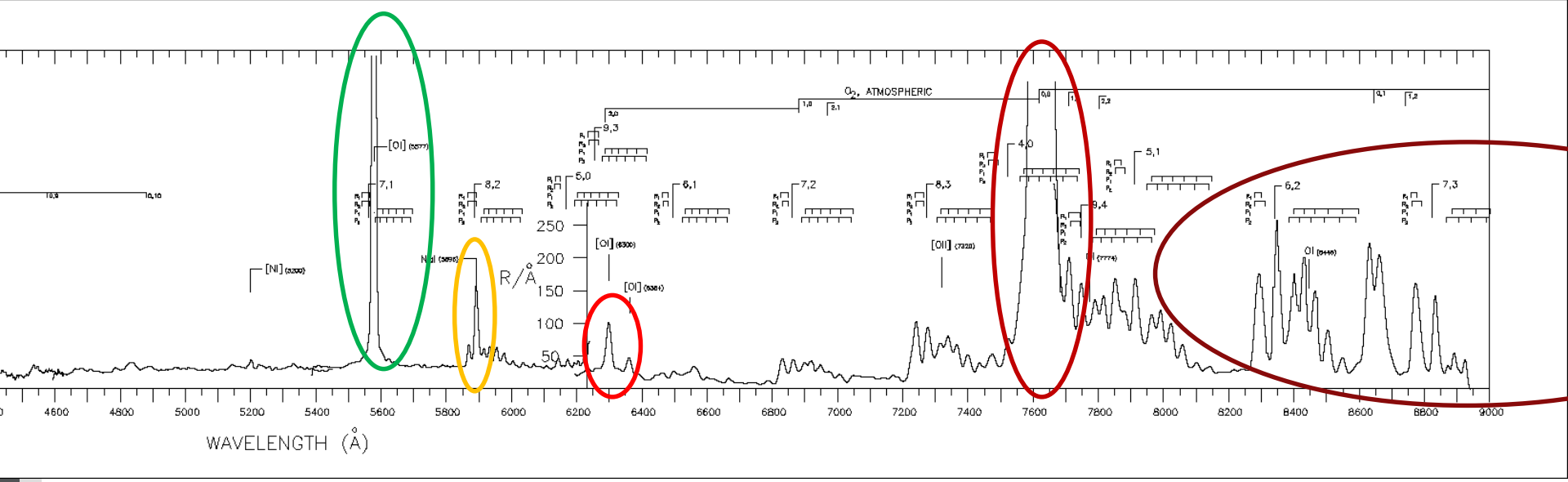
UV-VIS-NIR Nightsky Spectrum





Spectra recorded by GLO during the flight of STS-53, December 1992

Some remarks about the mesosphere

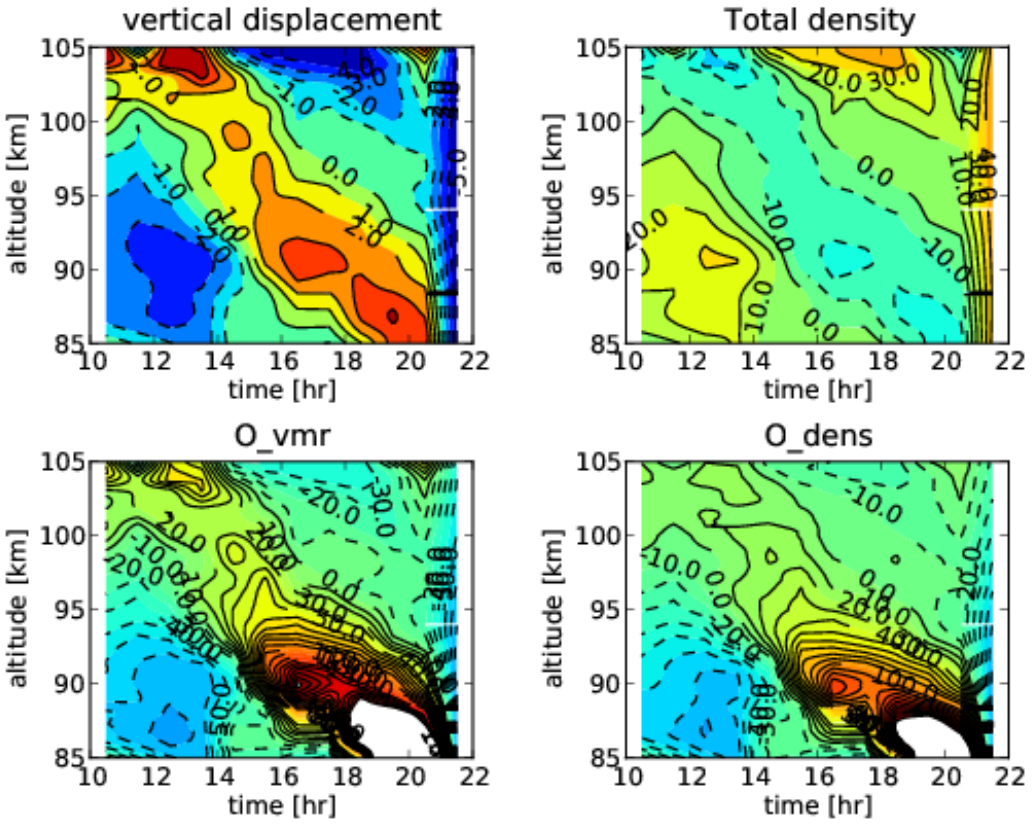
- Marks end of fully mixed atmosphere
- Highly dynamic region with marginal dynamical stability
  - waves break and turbulence structures are created
  - Wave amplitudes are largest (GWs, tides)
- Interface region between space and lower atmosphere
- Important Species:
  - O, H, O_3, NO, CO_2, H_2O, OH (O_2*, O*, OH*)
  - Photochemically driven; diurnal variations of many species
  - Ions

Importance of Atomic Oxygen on 15 um Temperature Retrieval

MIPAS/SABER
Temperature Errors
Due to Atomic Oxygen

Altitude	T-Uncertainty
70 km	1 K
80 km	1 K
90 km	2 K
100 km	7 K
110 km	19 K

Courtesy of A. Kutepov, 2015



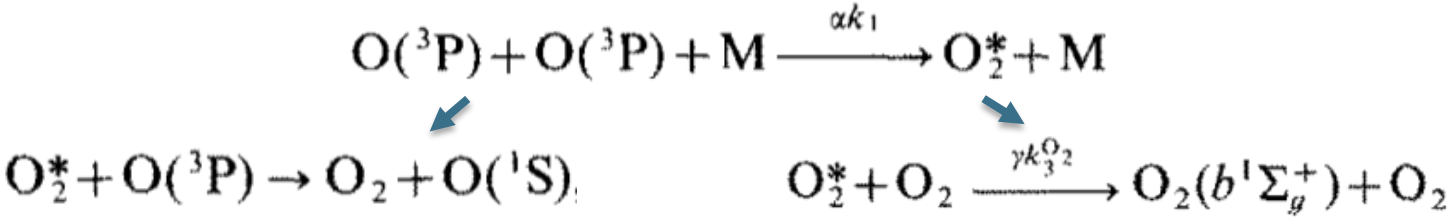
-> Temperature amplitudes due to tides / GWs highly affected by [O]
-> Simultaneous measurement (and retrieval) of T, [O] (and [CO_2]) very important

Retrieval of CO_2, O_3 and NO depends on atomic oxygen (a-priori) knowledge as well

How to measure atomic oxygen globally?

- fine structure emissions at 63um and 147 um (Grossmann et al., 2001) (> 120 km)

- Afterglow of O+O recombination (90-130 km)



red + green line emissions

atmospheric bands

ER ≈ O^2 - O^3

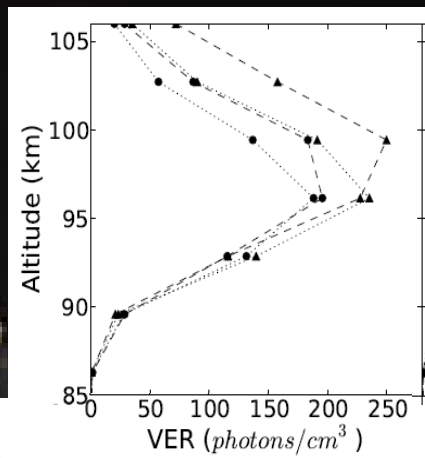
- measure OH* ← H+O_3 and H + O_3 ↔ O + O_2 + M (80-95 km)

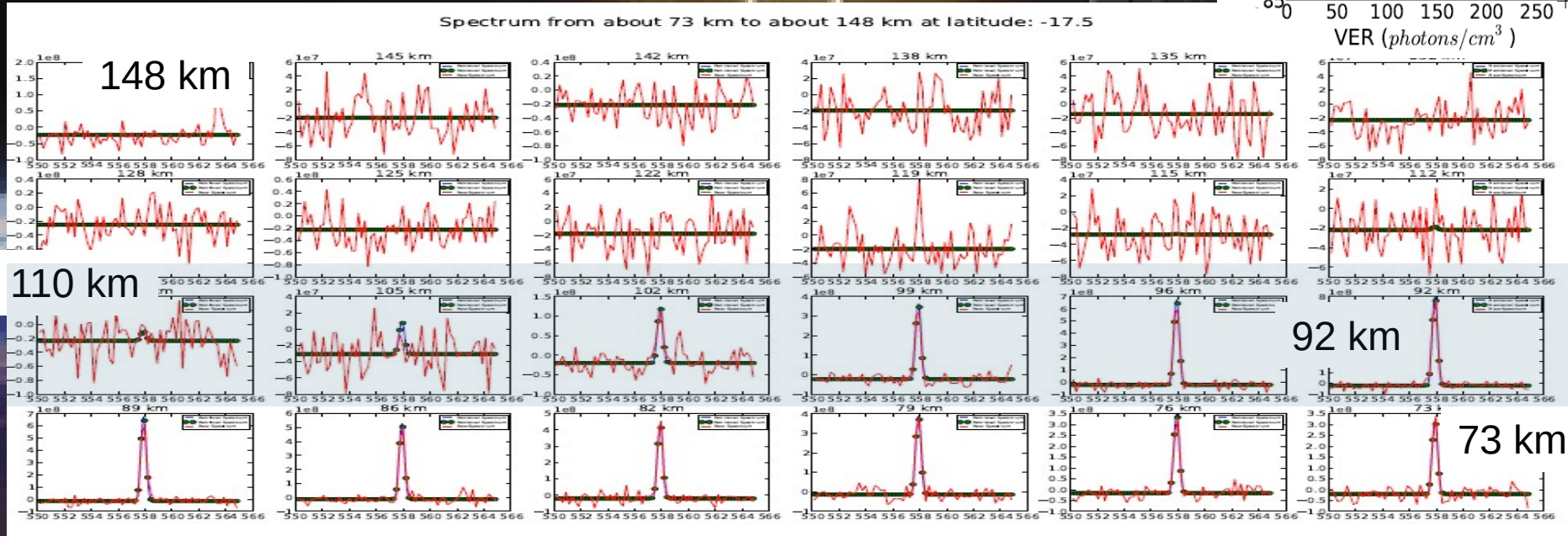
ER ≈ O^1

- Photochemical equilibrium with O_3

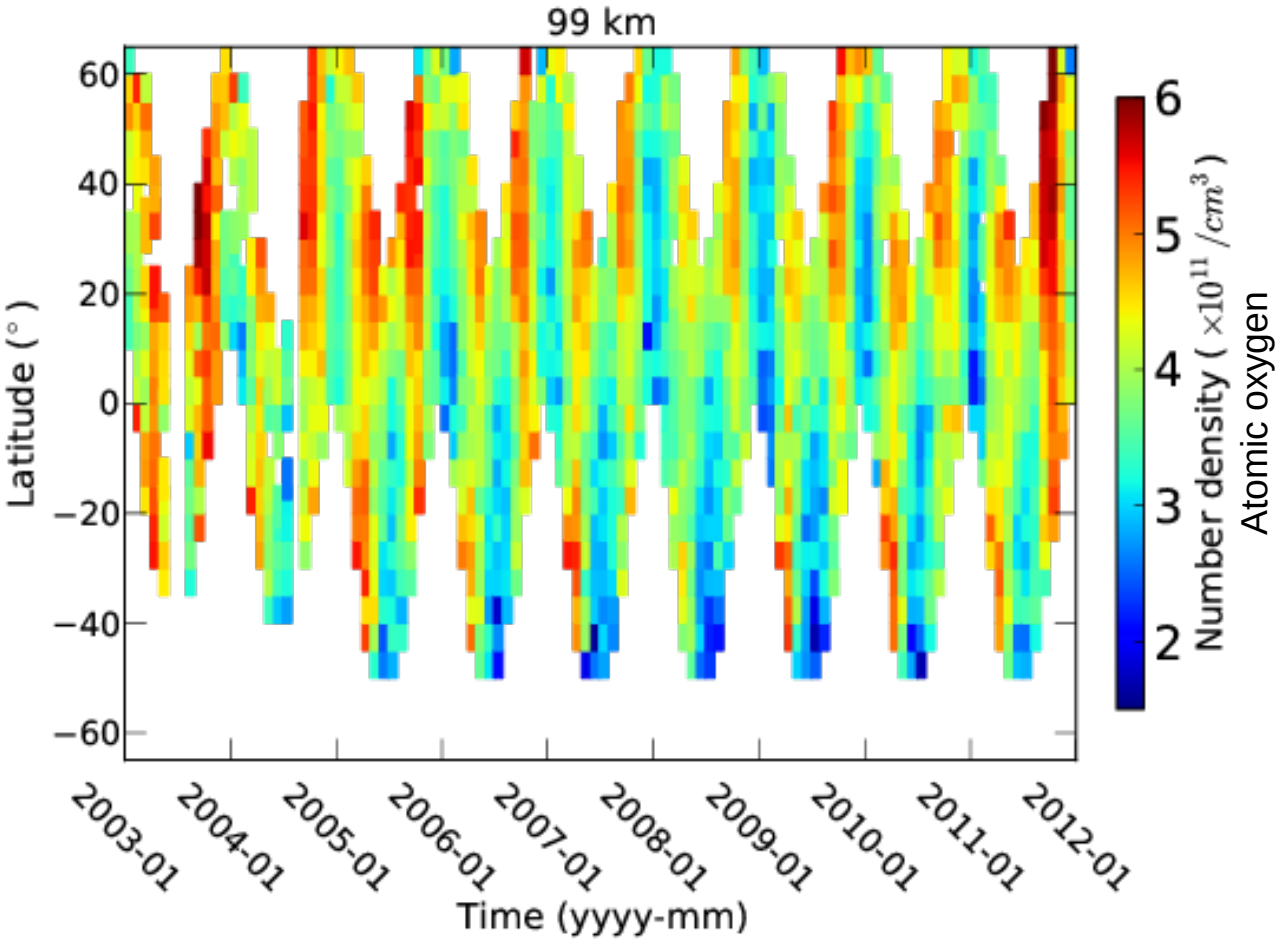
SCIAMACHY on Envisat

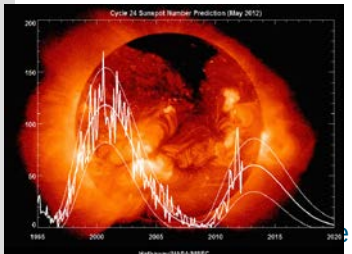
Nighttime limb measurements
Green line: 557 nm, channel 3





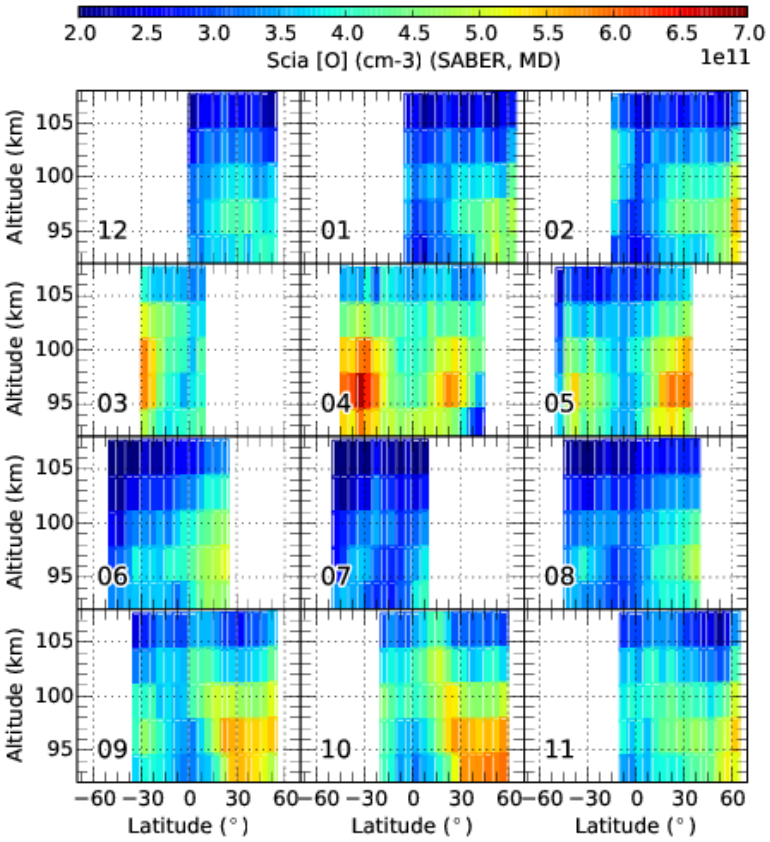
Spatio-temporal distribution of SCIAMACHY nighttime limb data





This pattern is caused by solar illumination and various calibration measurements on the night side of the satellite orbit

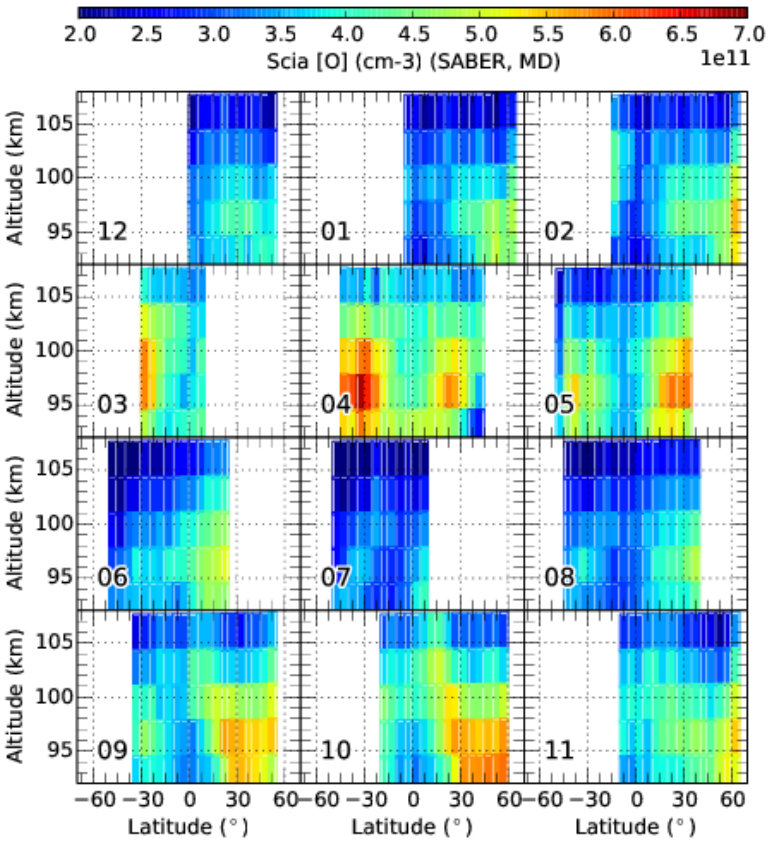
Latitudinal distribution of atomic oxygen densities



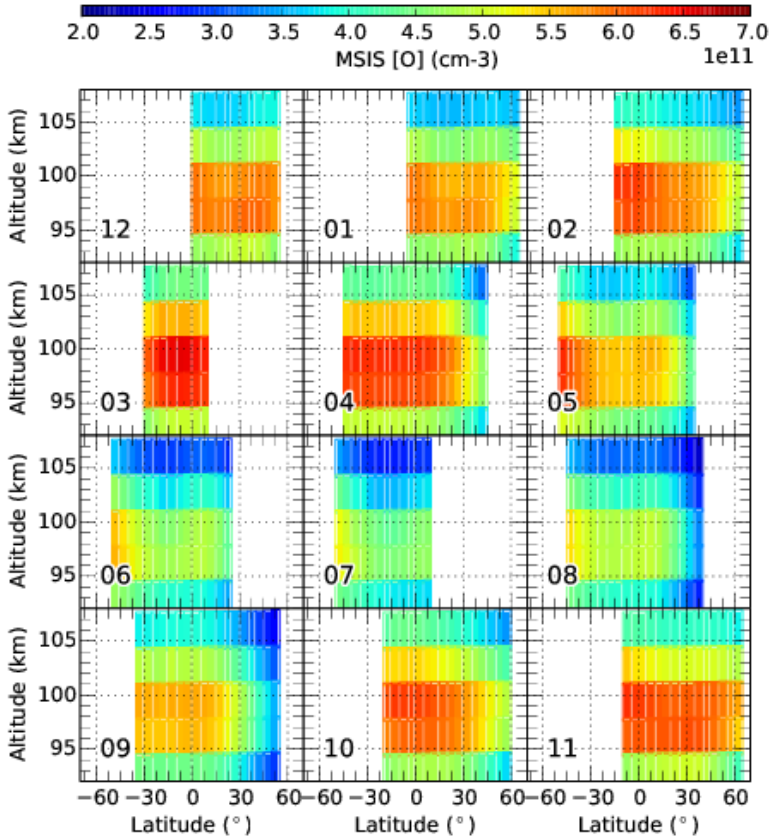
- Max @ 95 km
- [O](equinox) > [O](solstice)
- Max @ mid latitudes
- tides

Latitudinal distribution of atomic oxygen densities

SCIAMACHY

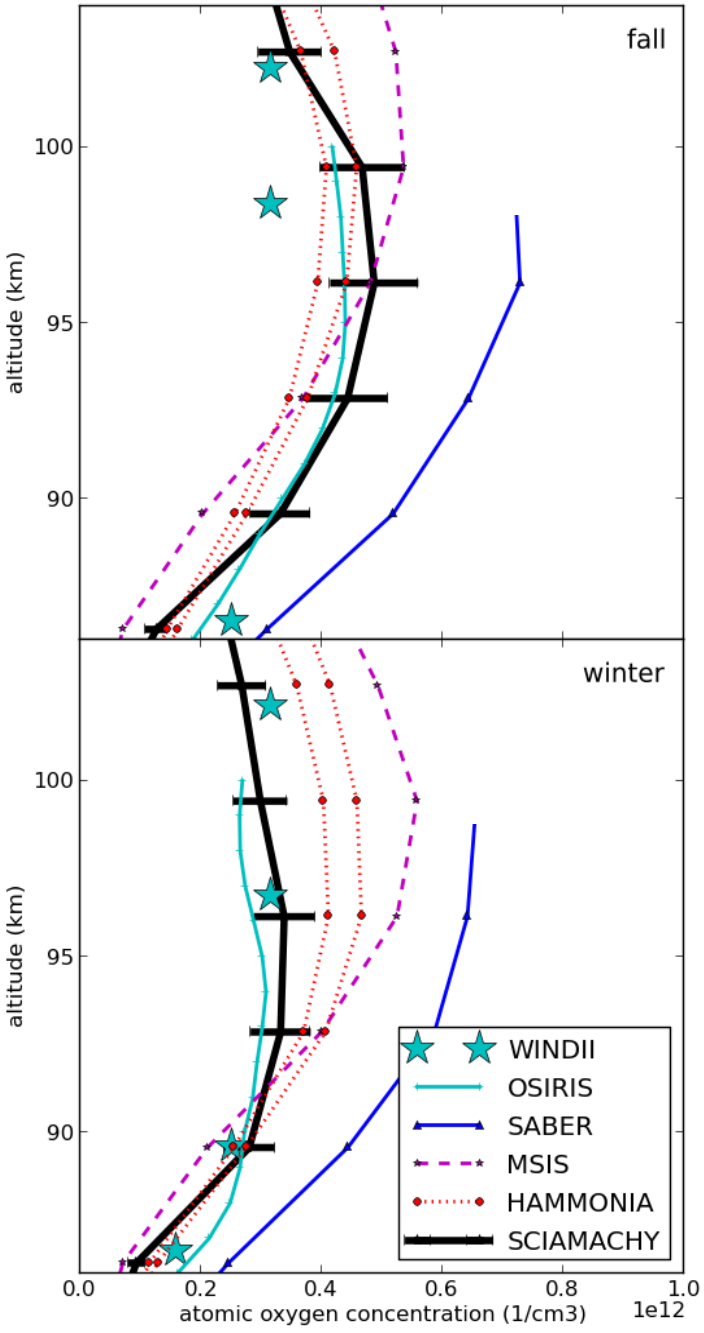


MSIS

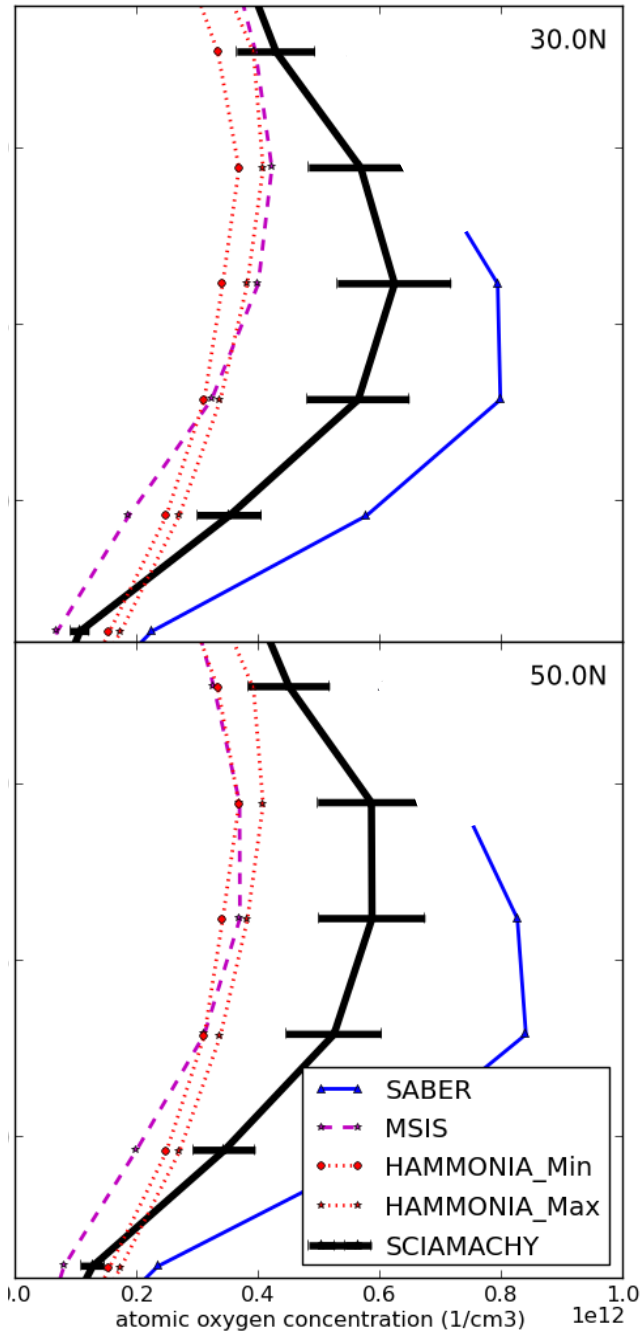


- 2007
- monthly and zonal means at 10 pm
- latitudinal structure caused by atmospheric tides

Equator, fall and winter



30N and 50N, fall



Times:

SCIAMACHY:
2005 or 2005/2006

SABER:
2005 or 2005/2006

OSIRIS:
2005

WINDII:
1993 or 1993/1994

References:

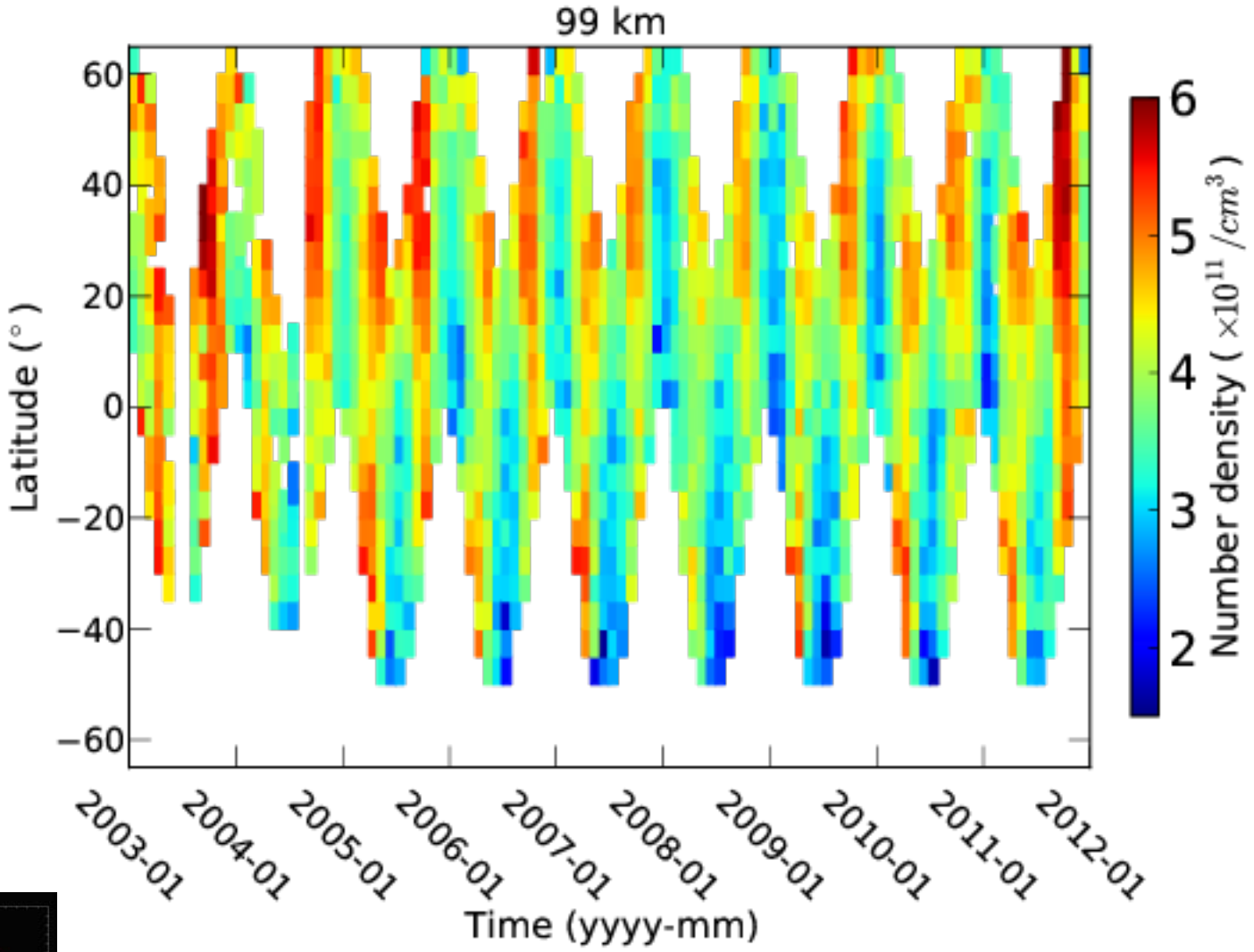
SABER:
Mlynczak et al., 2013

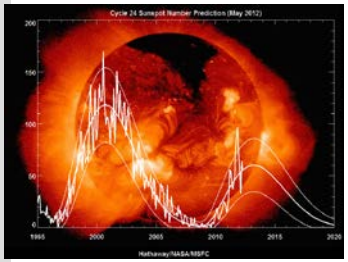
OSIRIS:
Sheese et al. 2011

WINDII:
Russel et al., 2005

HAMMONIA:
Schmidt, 2006

Spatio-temporal distribution of SCIAMACHY data





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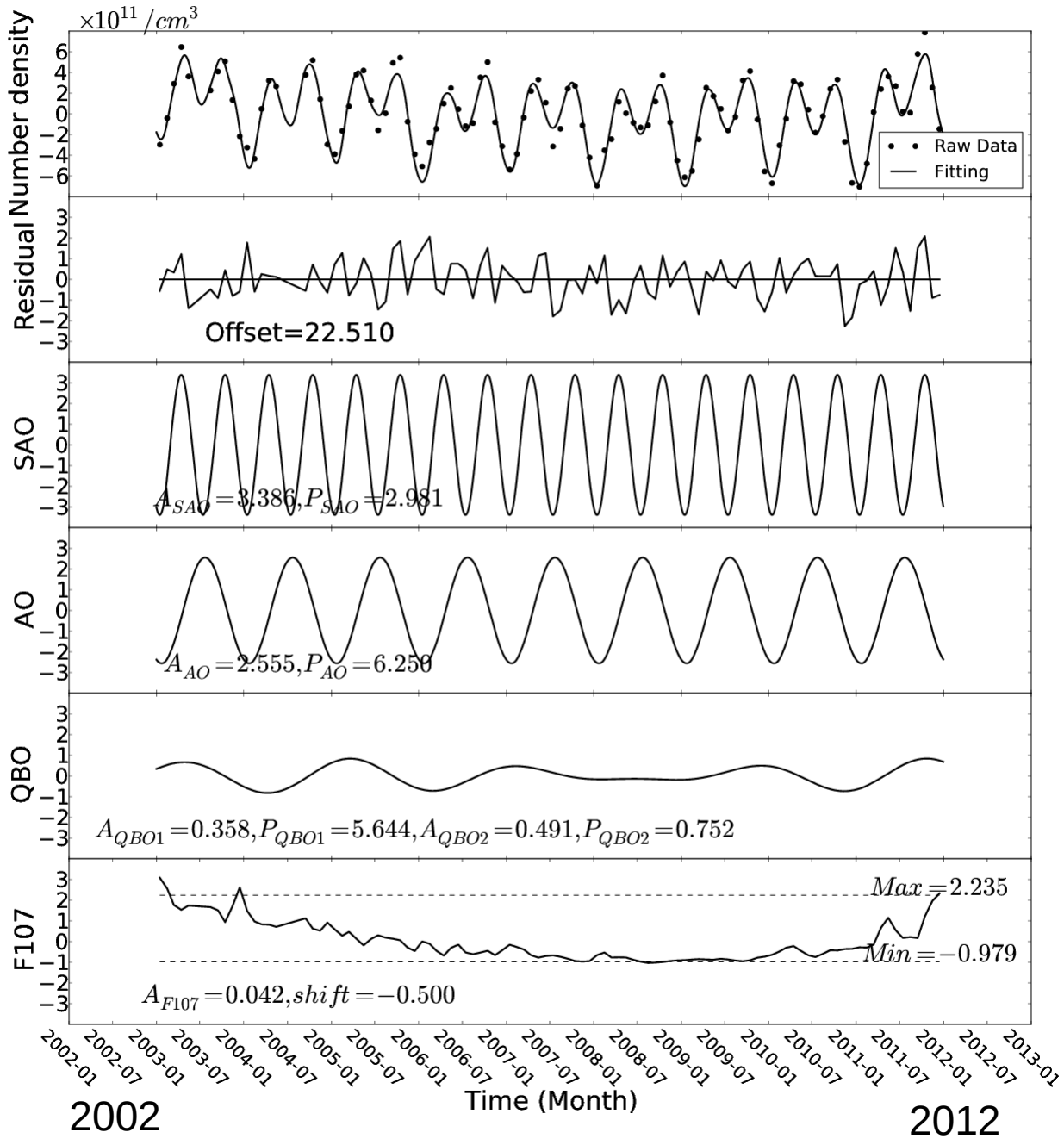
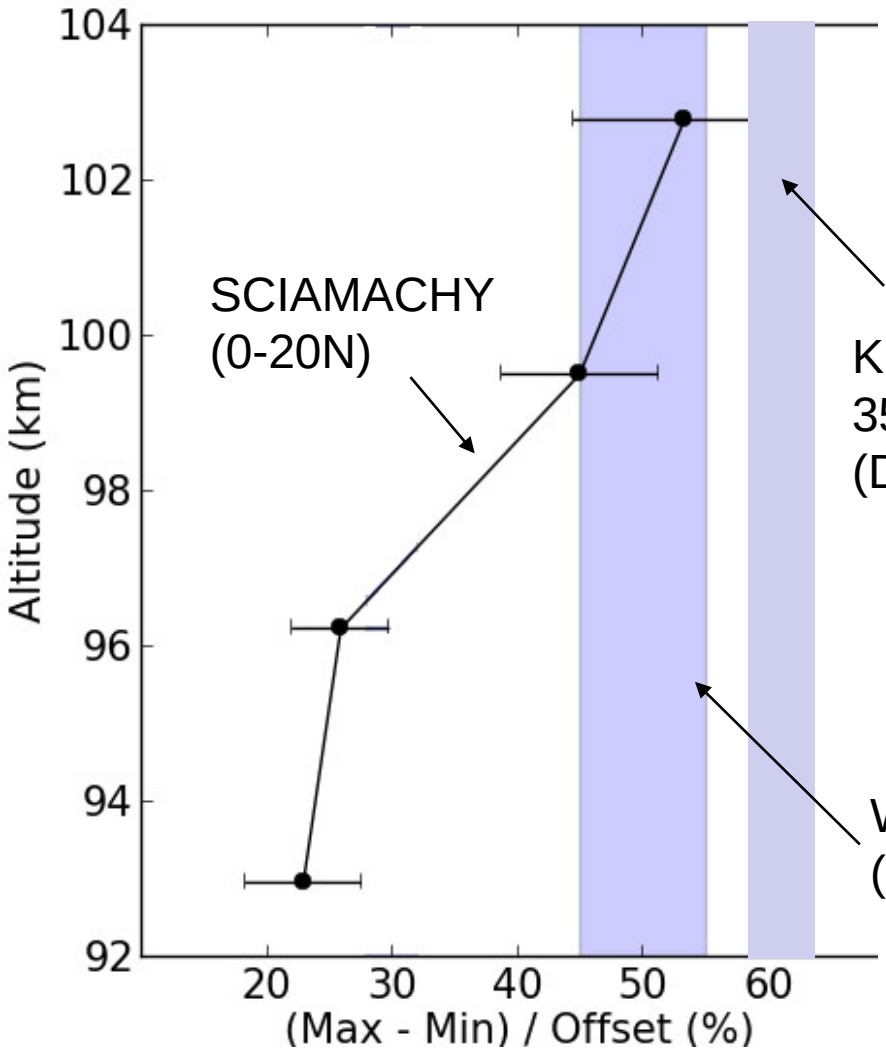
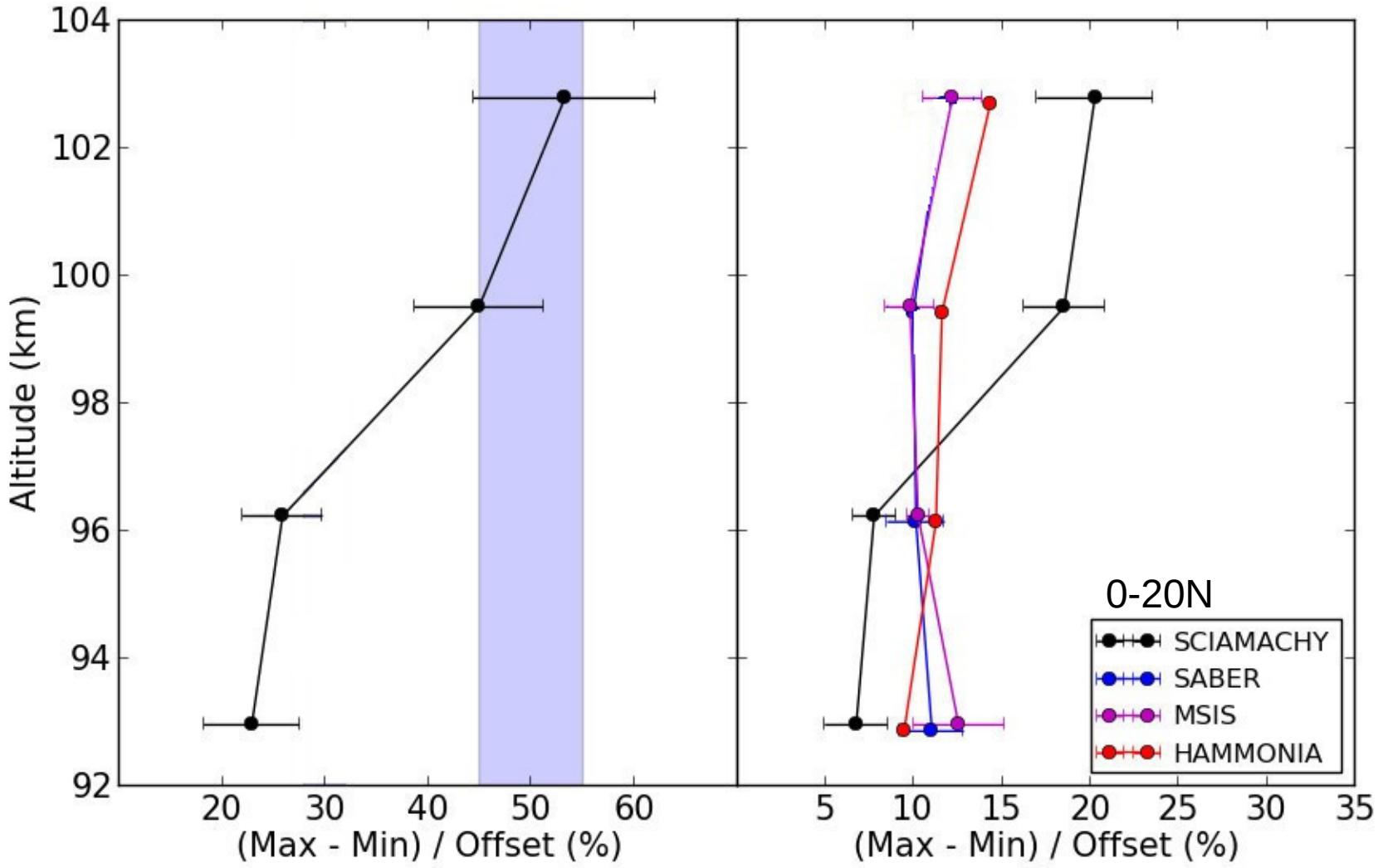

Number density
$\times 10^{11}\ /cm^3$
Raw Data
Fitting
Residual
Offset=22.510
SAO
$A_{SAO}=3.386, P_{SAO}=2.981$
AO
$A_{AO}=2.555, P_{AO}=6.259$
QBO
$A_{QBO1}=0.358, P_{QBO1}=5.644, A_{QBO2}=0.491, P_{QBO2}=0.752$
F107
$Max=2.235$
$Min=-0.979$
$A_{F107}=0.042, shift=-0.500$
2002-01
2002-07
2003-01
2003-07
2004-01
2004-07
2005-01
2005-07
2006-01
2006-07
2007-01
2007-07
2008-01
2008-07
2009-01
2009-07
2010-01
2010-07
2011-01
2011-07
2012-01
2012-07
2013-01
Time (Month)
2002
2012

11 yr solar max-min difference, radiances



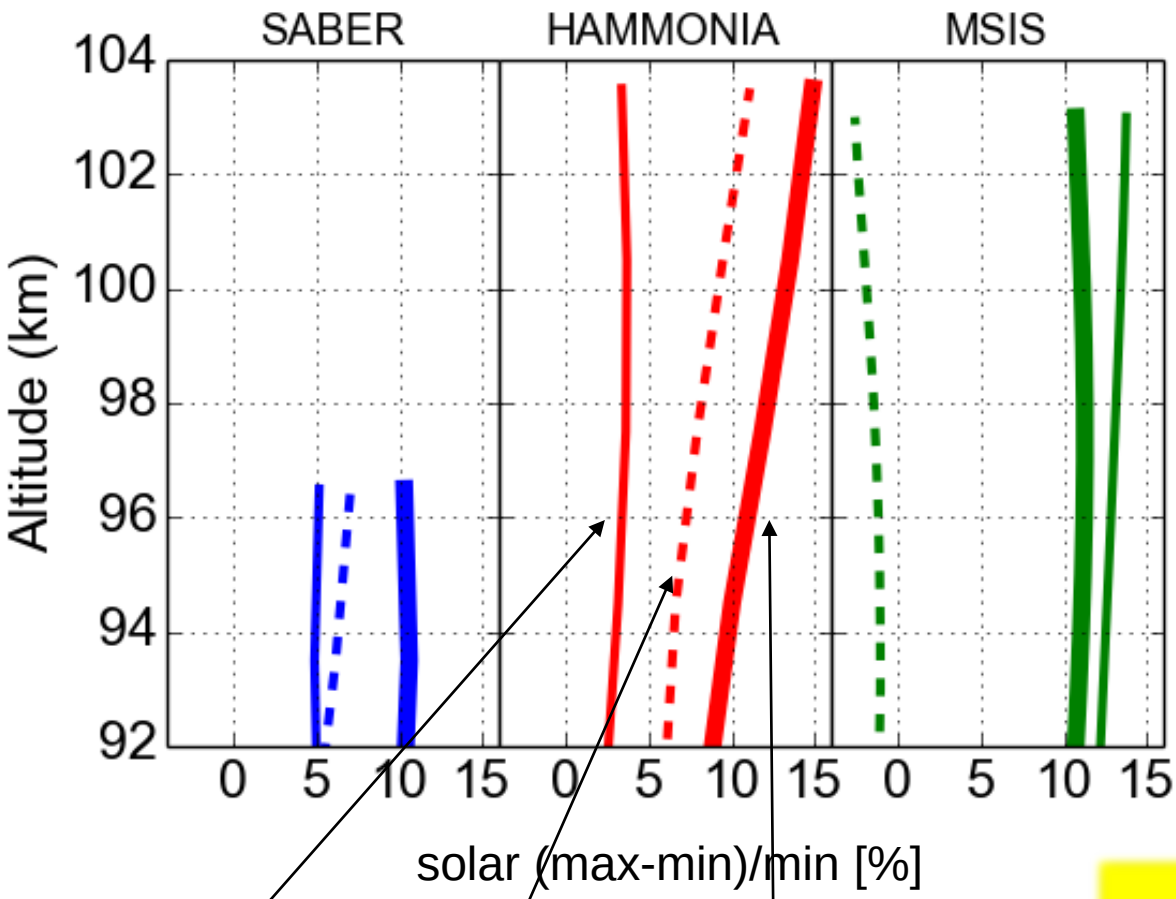
11 yr solar max-min difference, atomic oxygen density



radiances / volume emission rates

atomic oxygen density

11 yr solar max-min difference: atomic oxygen & total density



O volume mixing ratio

total density [1/cm^3]

O density [1/cm^3]

11 yr solar cycle affects total density more than atomic oxygen vmr

Summary

SCIAMACHY data allows to derive a global dataset of atomic oxygen in the mesopause region

Absolute values:

- similar to WINDII and OSIRIS measurements
- SABER data is significantly larger (up to 50%)
- models differ up to 40% (smaller or larger)

11 yr solar cycle dependence:

- 7-20%, altitude dependent
- larger than model predictions

  models likely underestimate solar cycle in total density