Continuing Studies Using Solar Occultation Data

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SOSST Meeting, Williamsburg, VA

May 6-7, 2003

SOSST Research Activities at HU

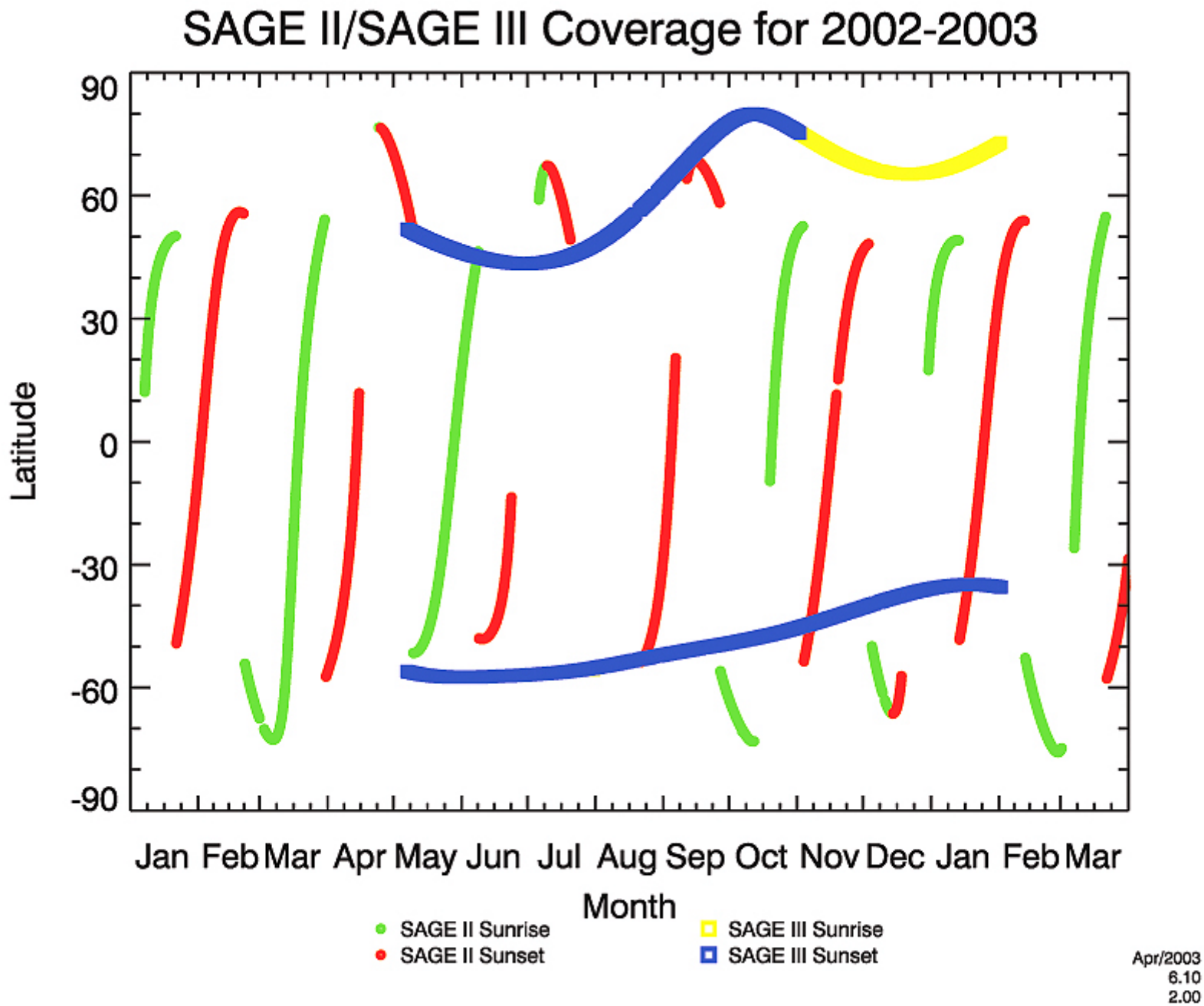
- **Validation studies of O3, aerosol, and other products. Intercomparisons of SAGE I/II/III, HALOE, POAM, ILAS, SBUV2, SABER, ozonesondes, and Umkehr measurements.**

- **Developing a "unified" ozone climatology including SAGE, ozonesonde, and HALOE data, and an aerosol climatology using SAM II/SAGE data.**

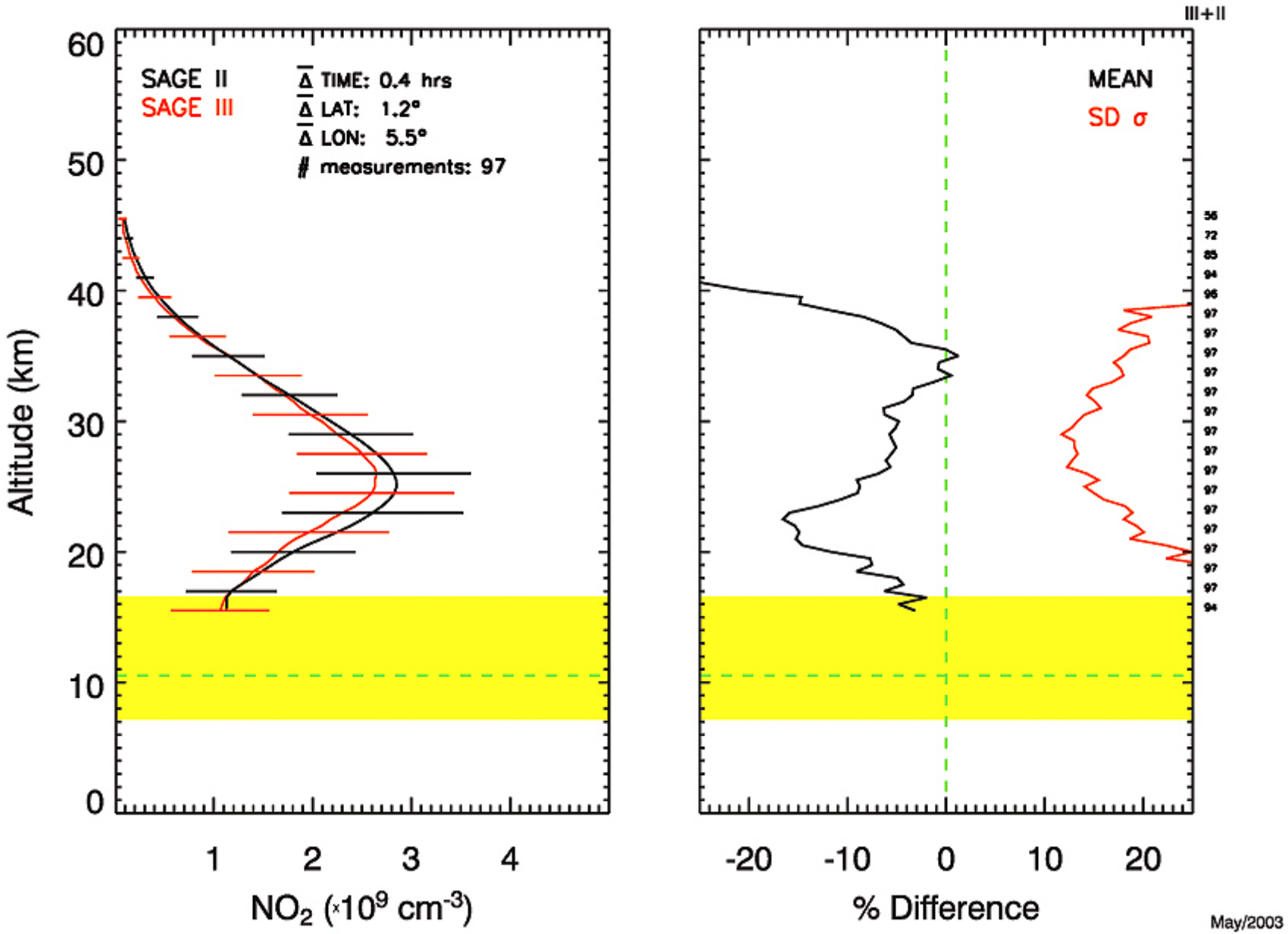
- **Ozone trend analyses using SAGE I/II/III data.**

Validation

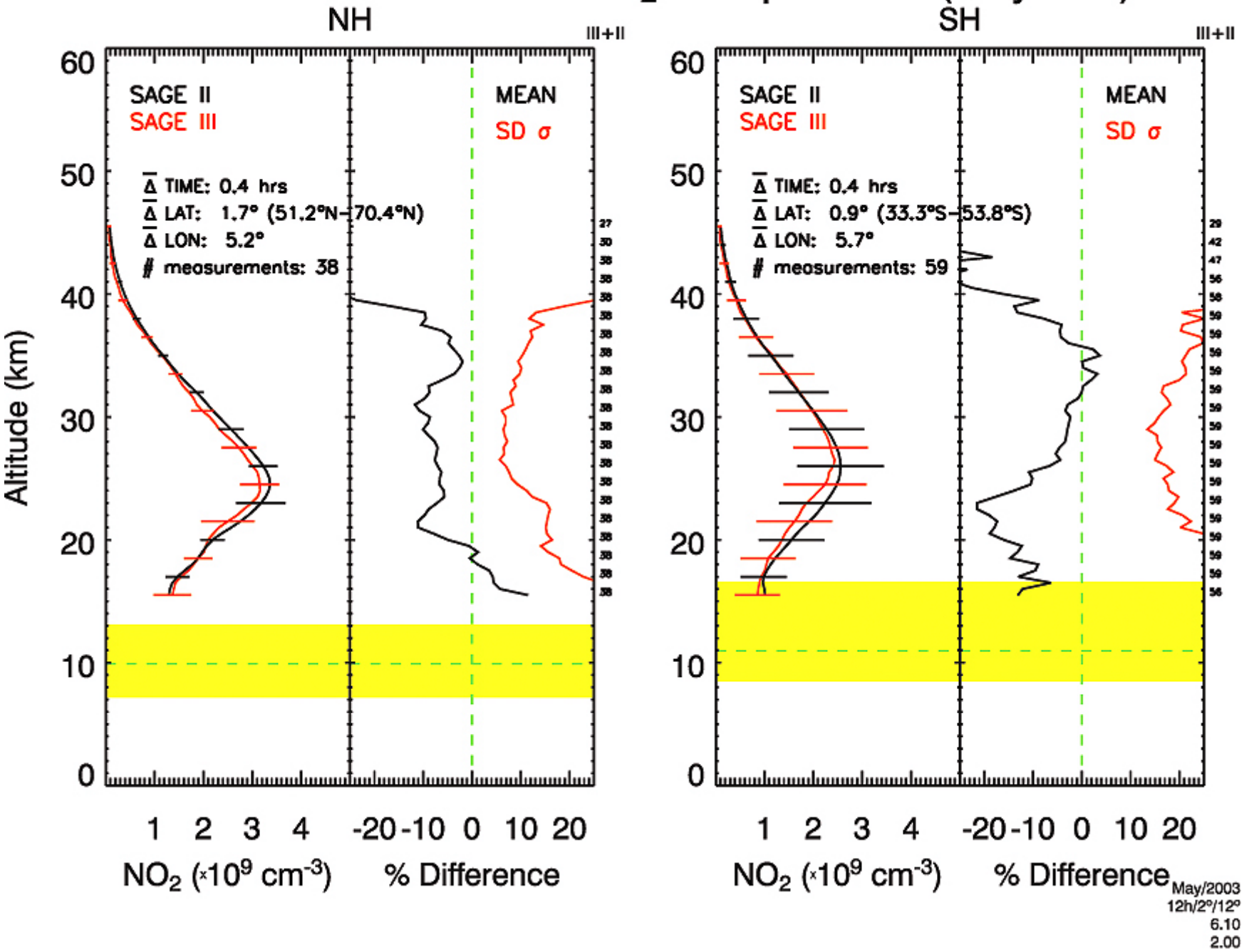
SAGE II and SAGE III Comparisons


SAGE II/SAGE III Coverage for 2002-2003
90
60
30
0
-30
-60
-90
Latitude
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar
Month
SAGE II Sunrise
SAGE II Sunset
SAGE III Sunrise
SAGE III Sunset
Apr/2003
6.10
2.00

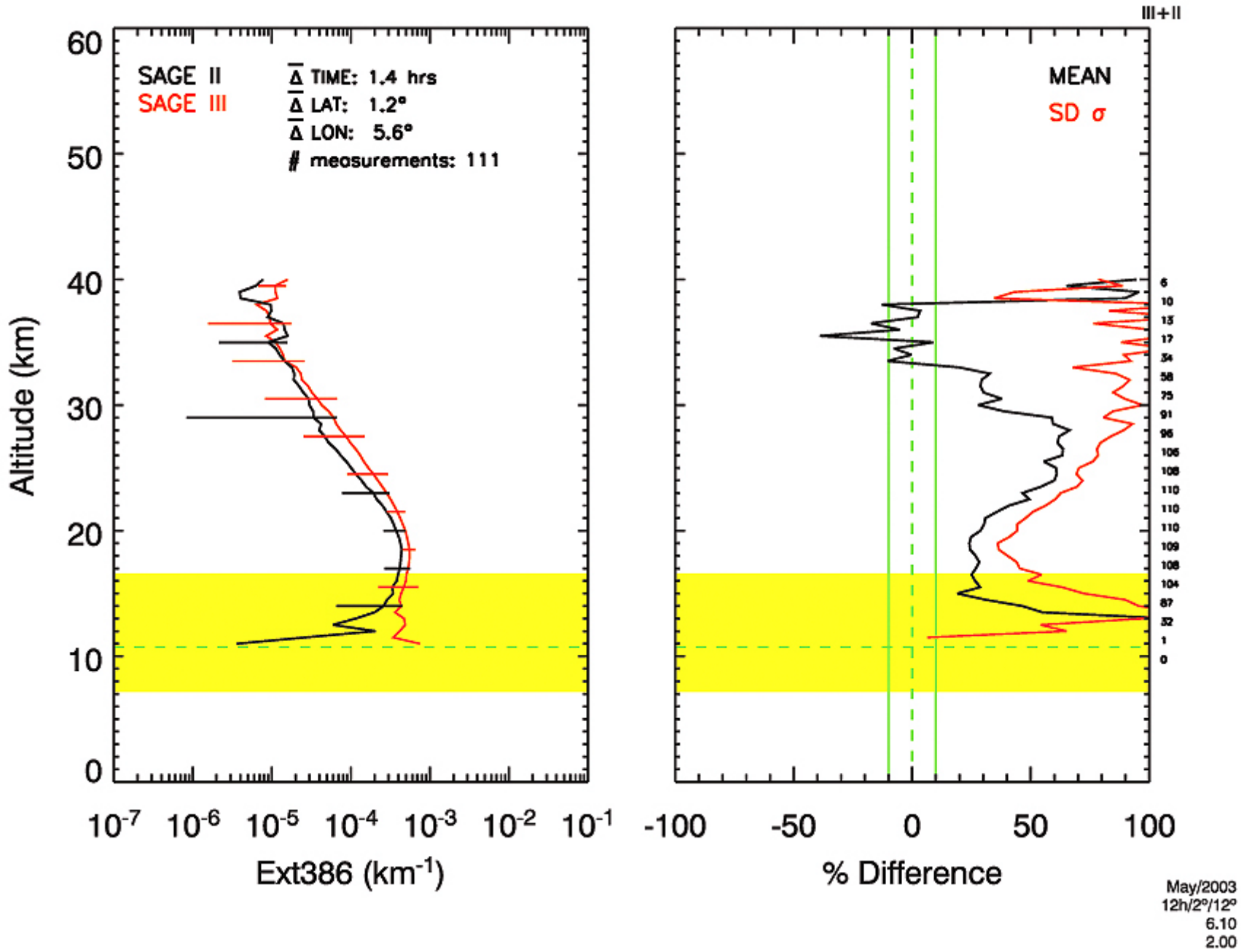
SAGE II/SAGE III SS NO_2 Comparisons (May-Feb)



SAGE II/SAGE III SS NO_2 Comparisons (May-Feb)



Composite of SAGE II/SAGE III Ext386 Comparisons (May-Feb)



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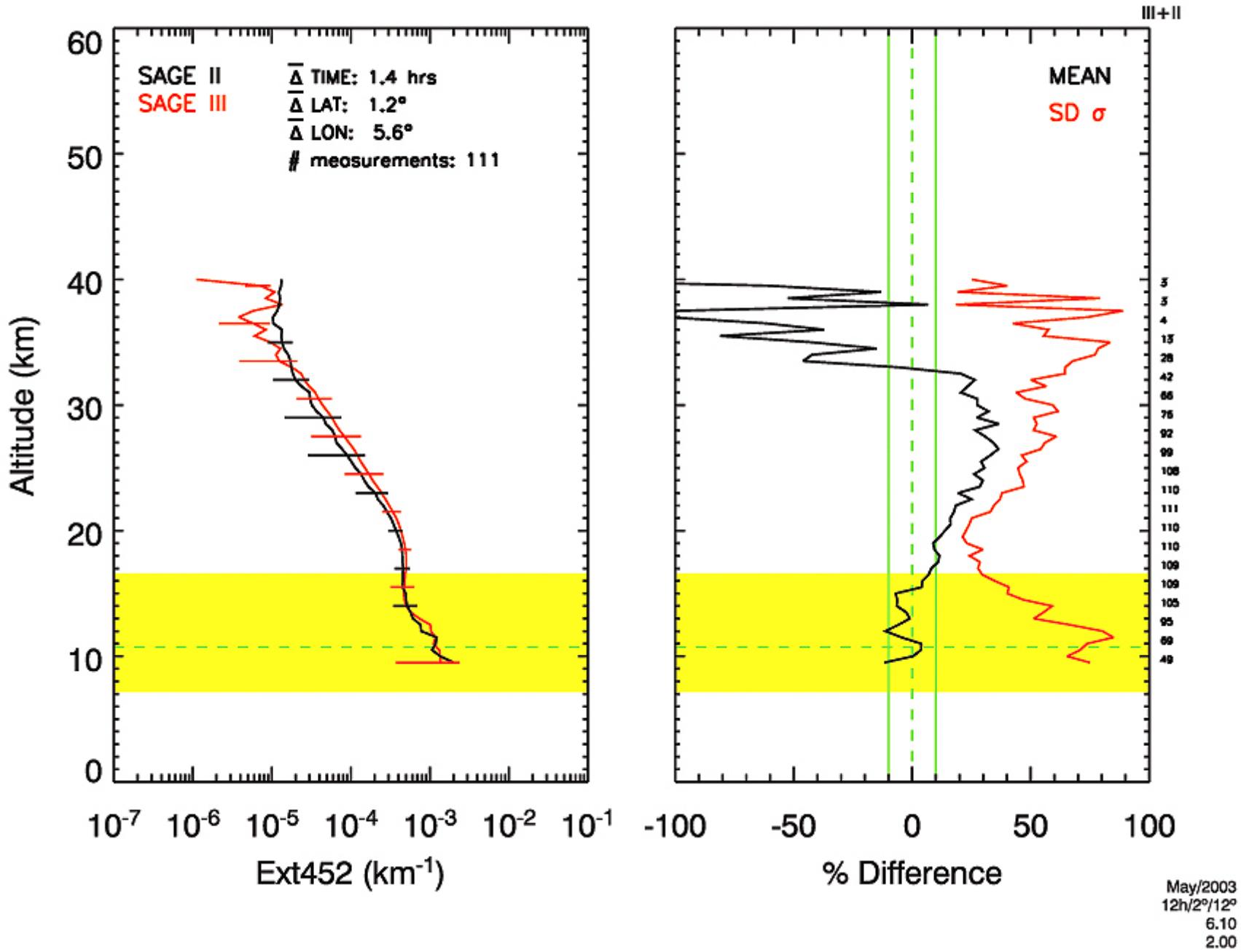
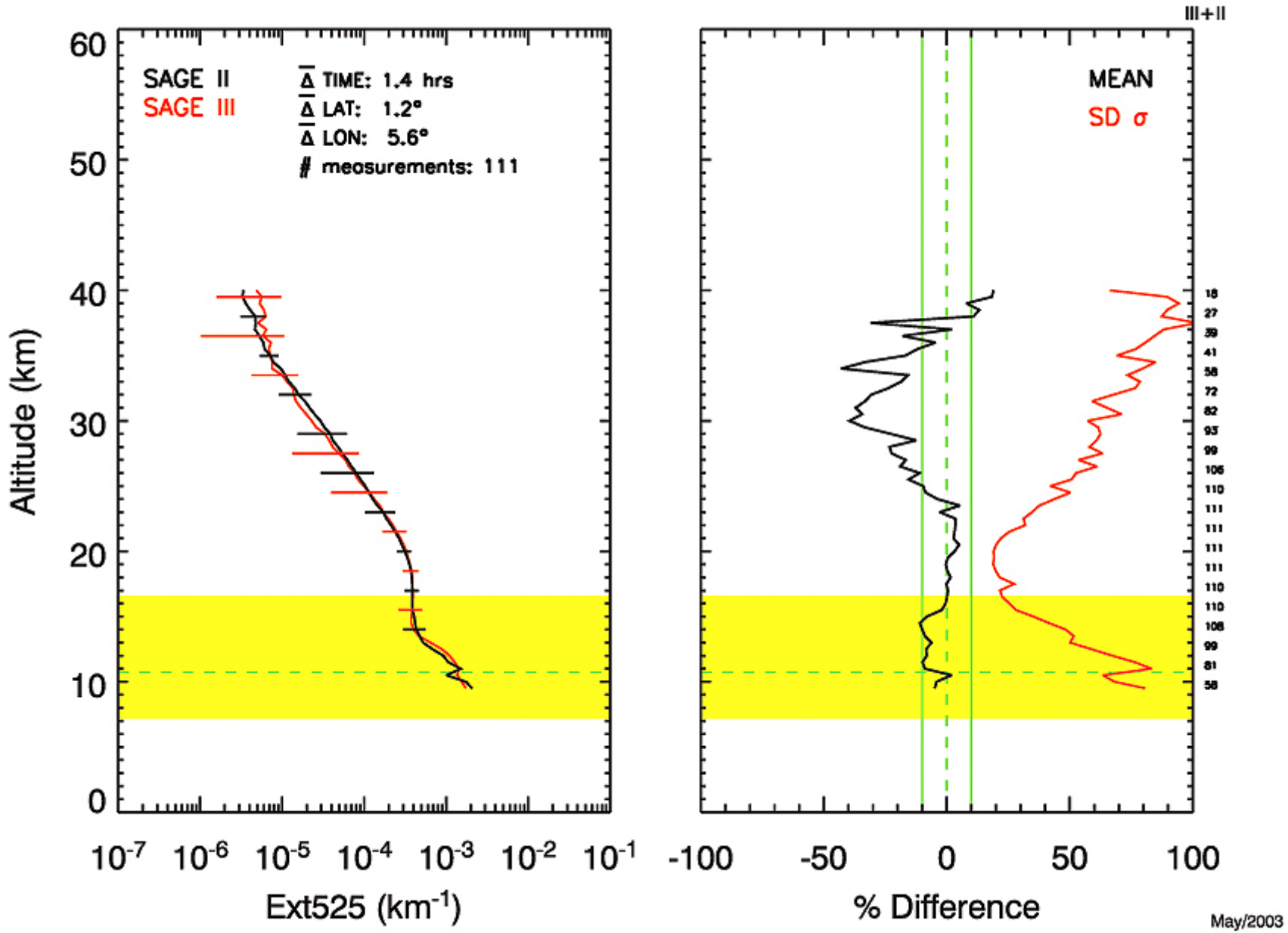
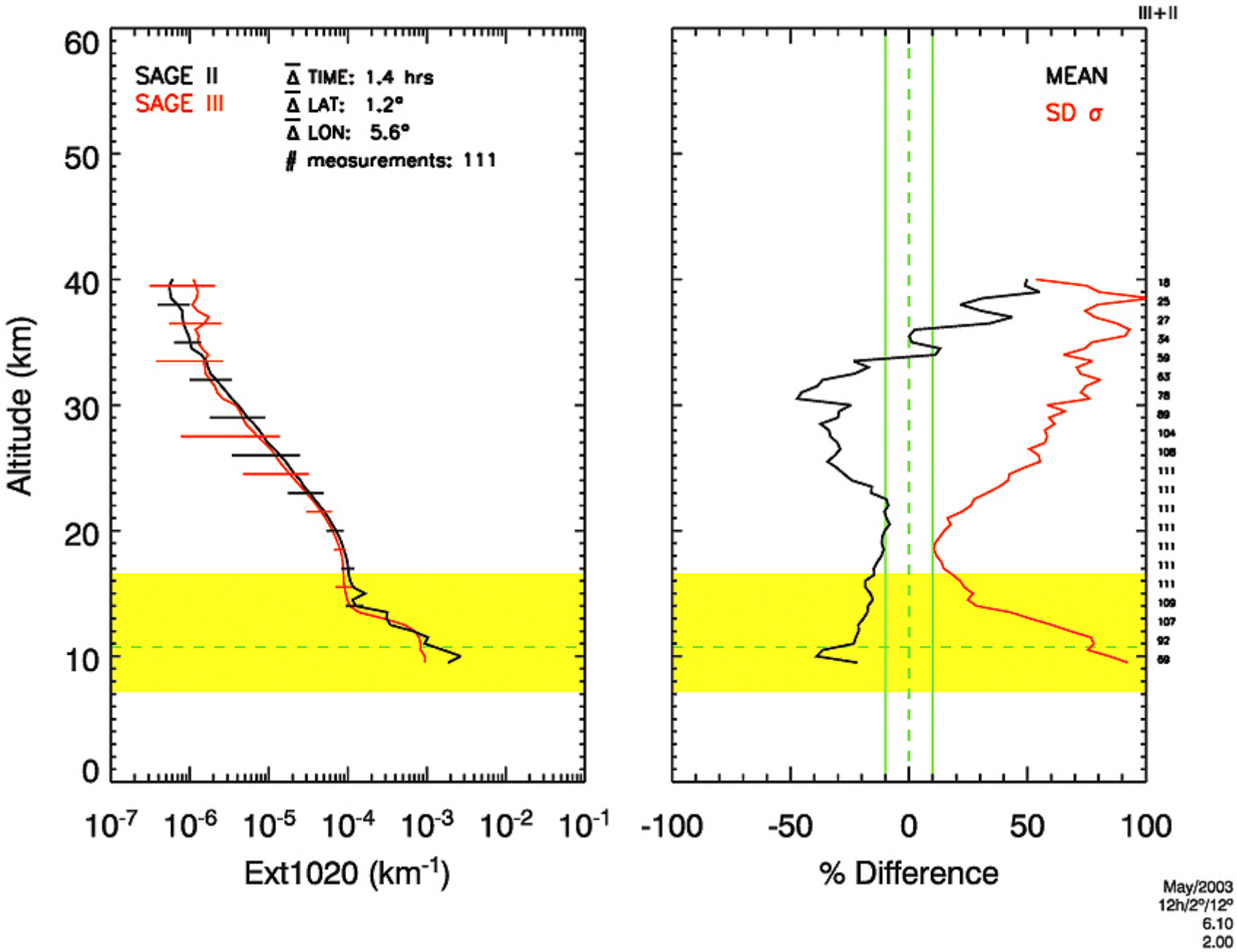


Composite of SAGE II/SAGE III Ext525 Comparisons (May-Feb)



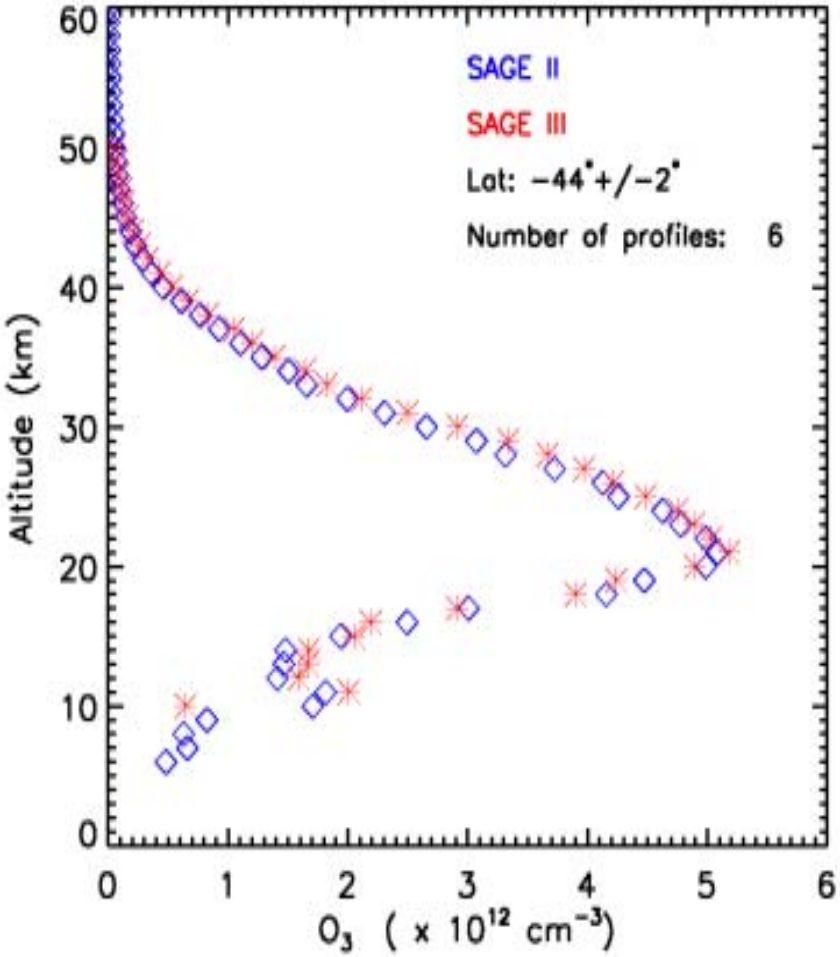
Composite of SAGE II/SAGE III Ext1020 Comparisons (May-Feb)

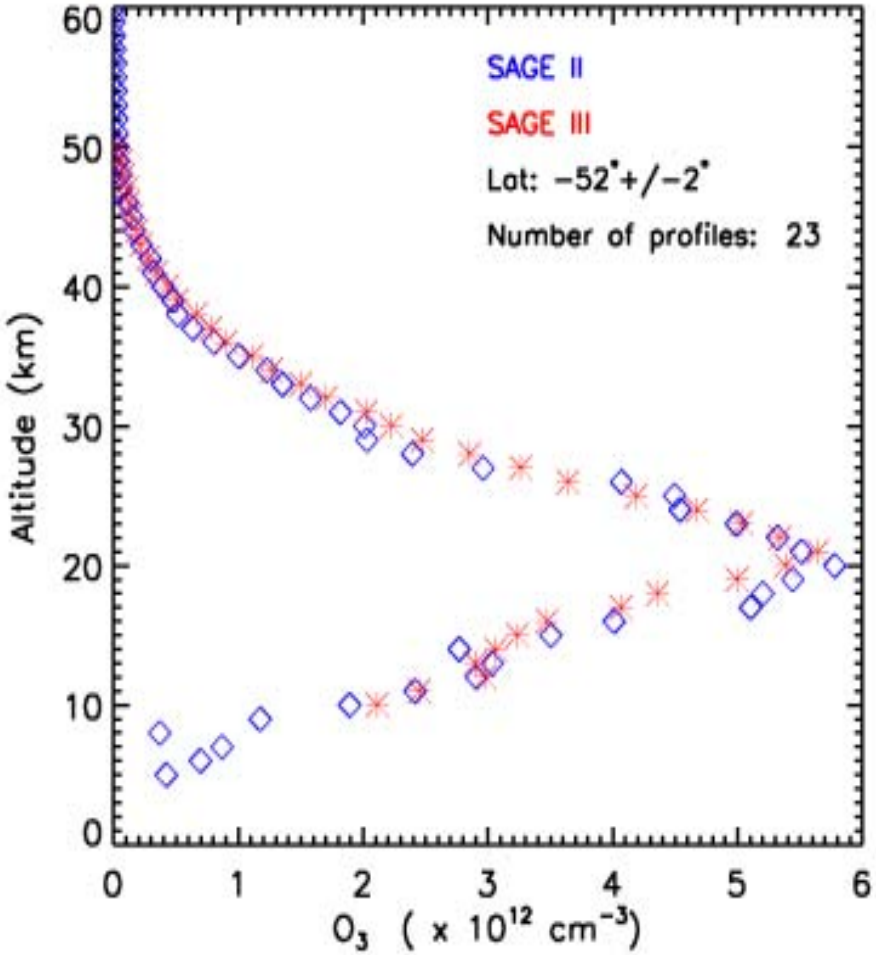


SAGE II AND SAGE III COMPARISONS

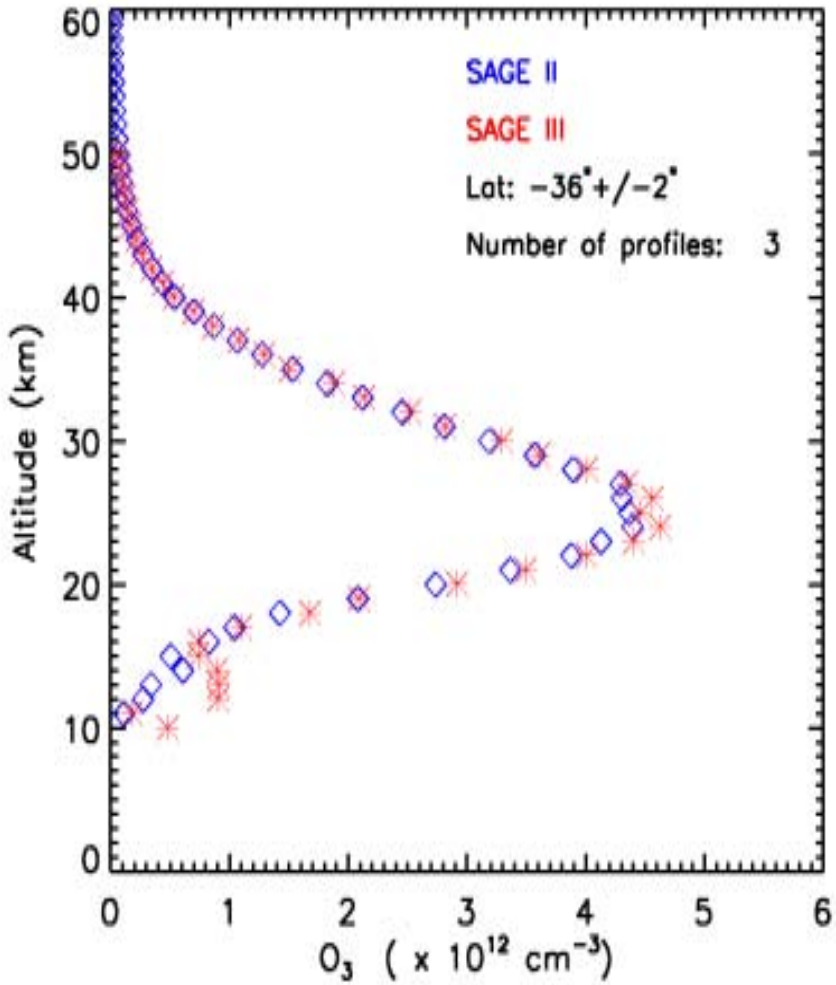
- In each latitude bin = 4°, profiles from the two instruments were matched using coincidence criteria (Δ Latitude < 1°, Δ longitude < 12°, time < 12 hours).
- Percent differences were calculated using the average of SAGE II and SAGE III as a reference.
- Weighted zonal means of percent differences for a particular latitude bin are obtained for the period 05/2002 – 02/2003.

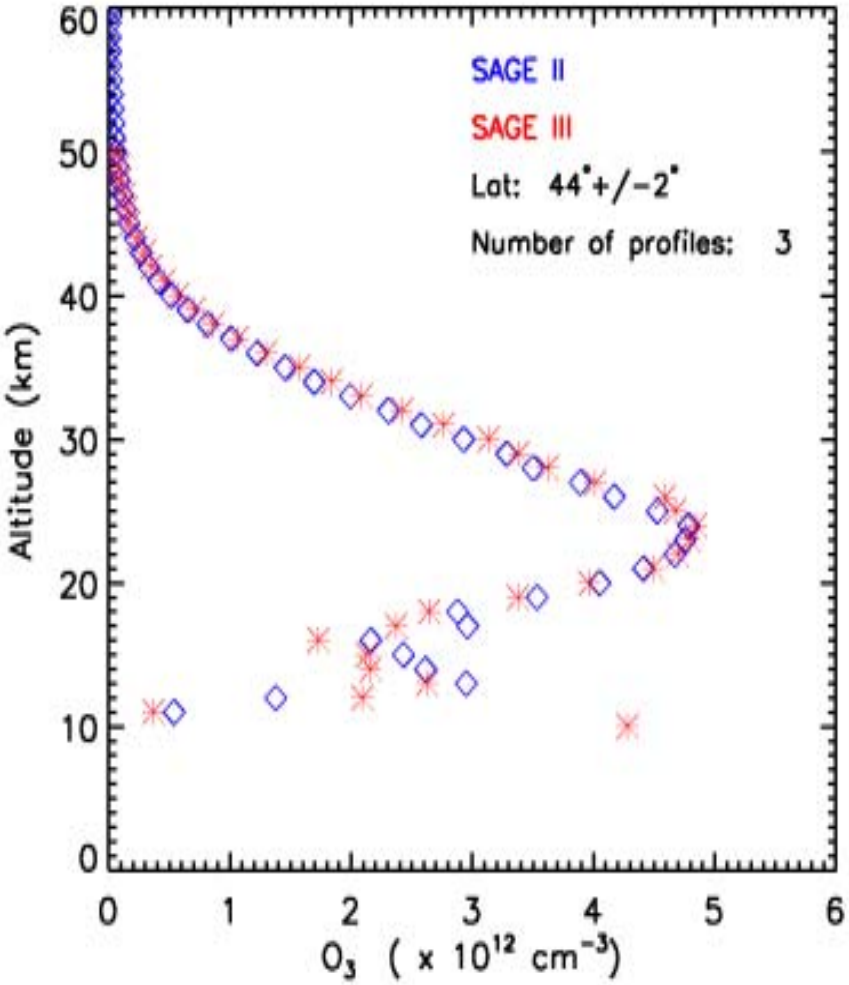
SAGE II AND SAGE III OZONE WEIGHTED MEAN PROFILES (Period 2002 - 2003)



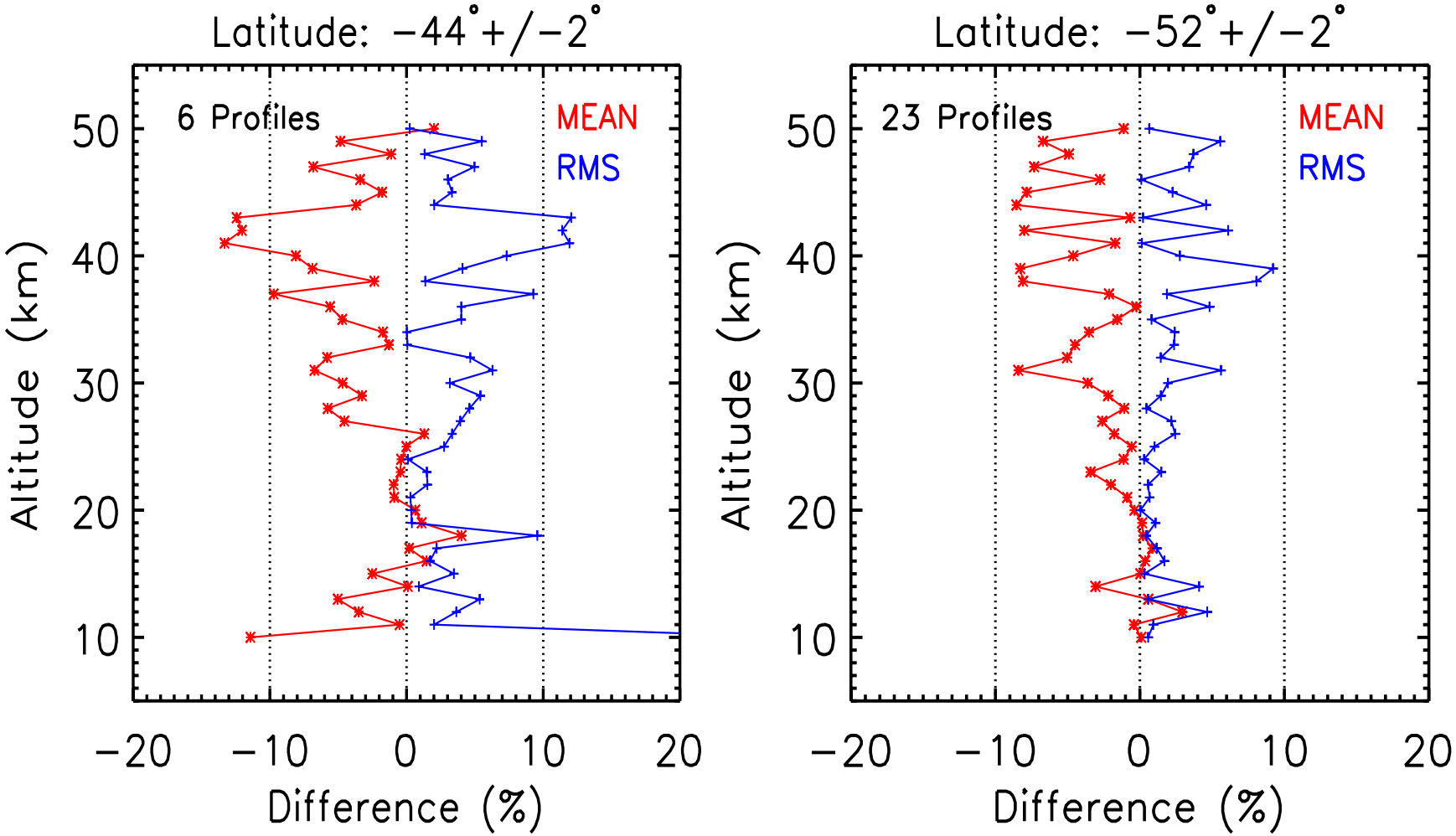


SAGE II AND SAGE III OZONE WEIGHTED MEAN PROFILES (Period 2002 - 2003)

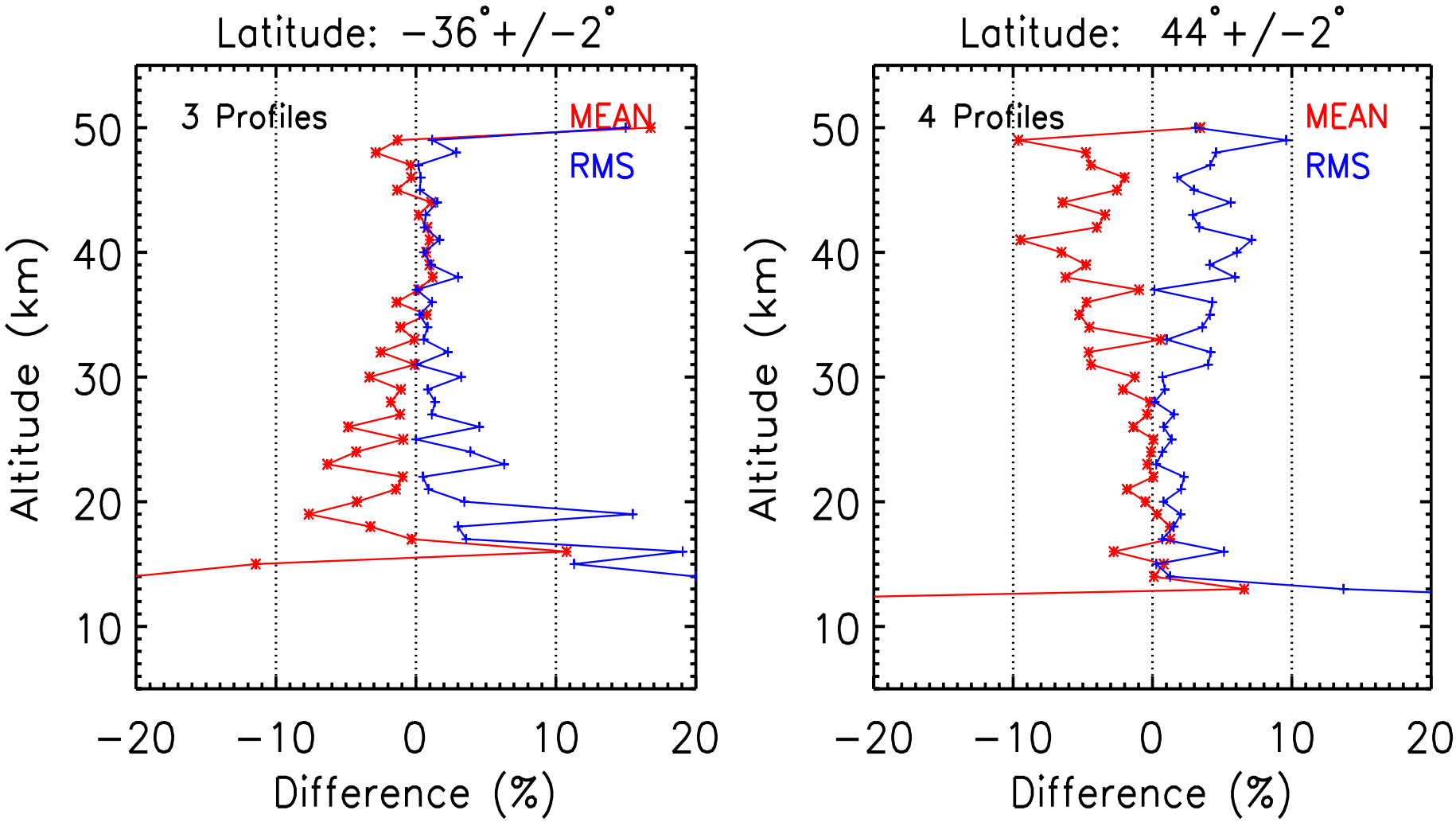




PERCENT DIFFERENCE BETWEEN SAGE II AND SAGE III (Period 2002 - 2003)

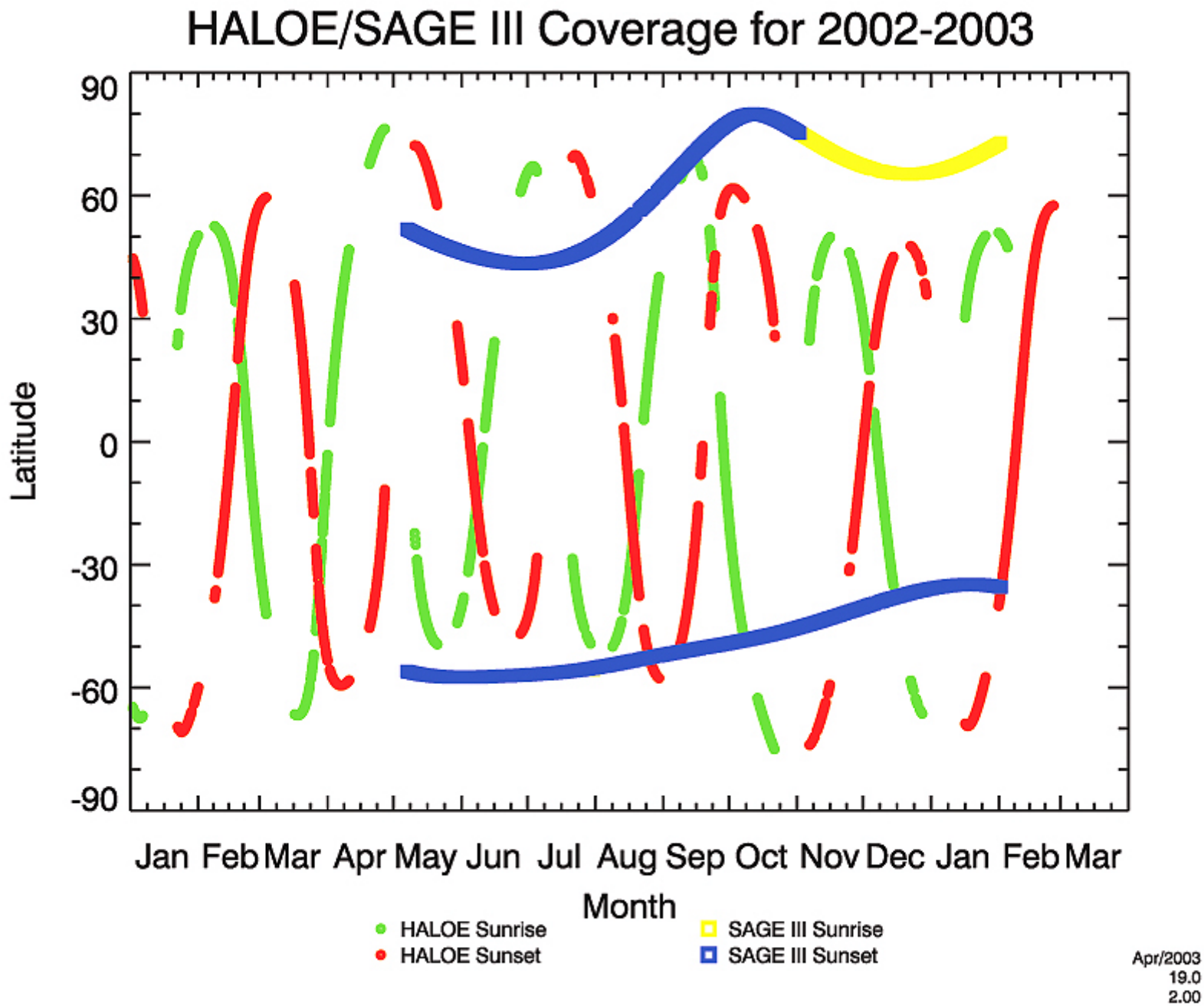


PERCENT DIFFERENCE BETWEEN SAGE II AND SAGE III (Period 2002 - 2003)

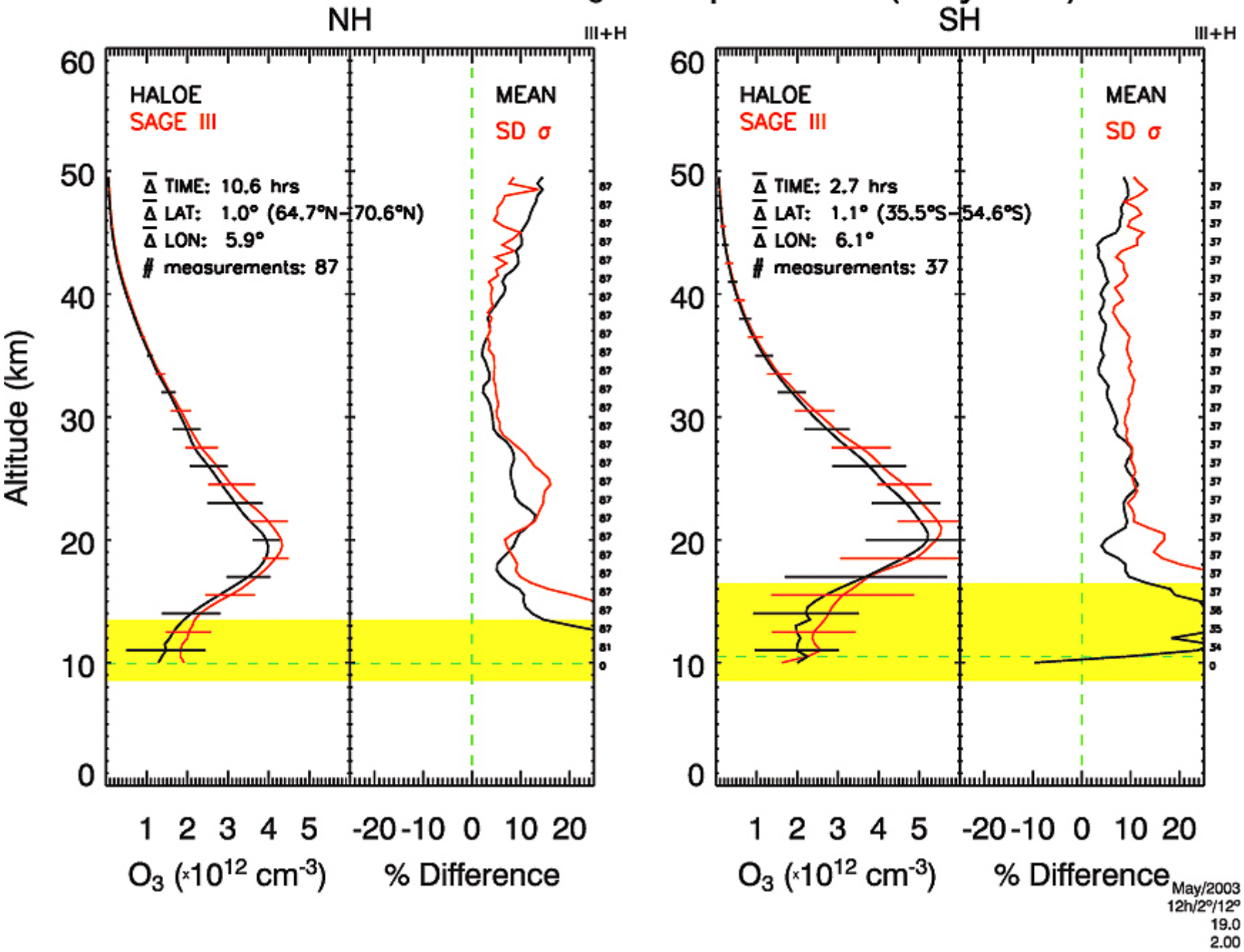


Validation

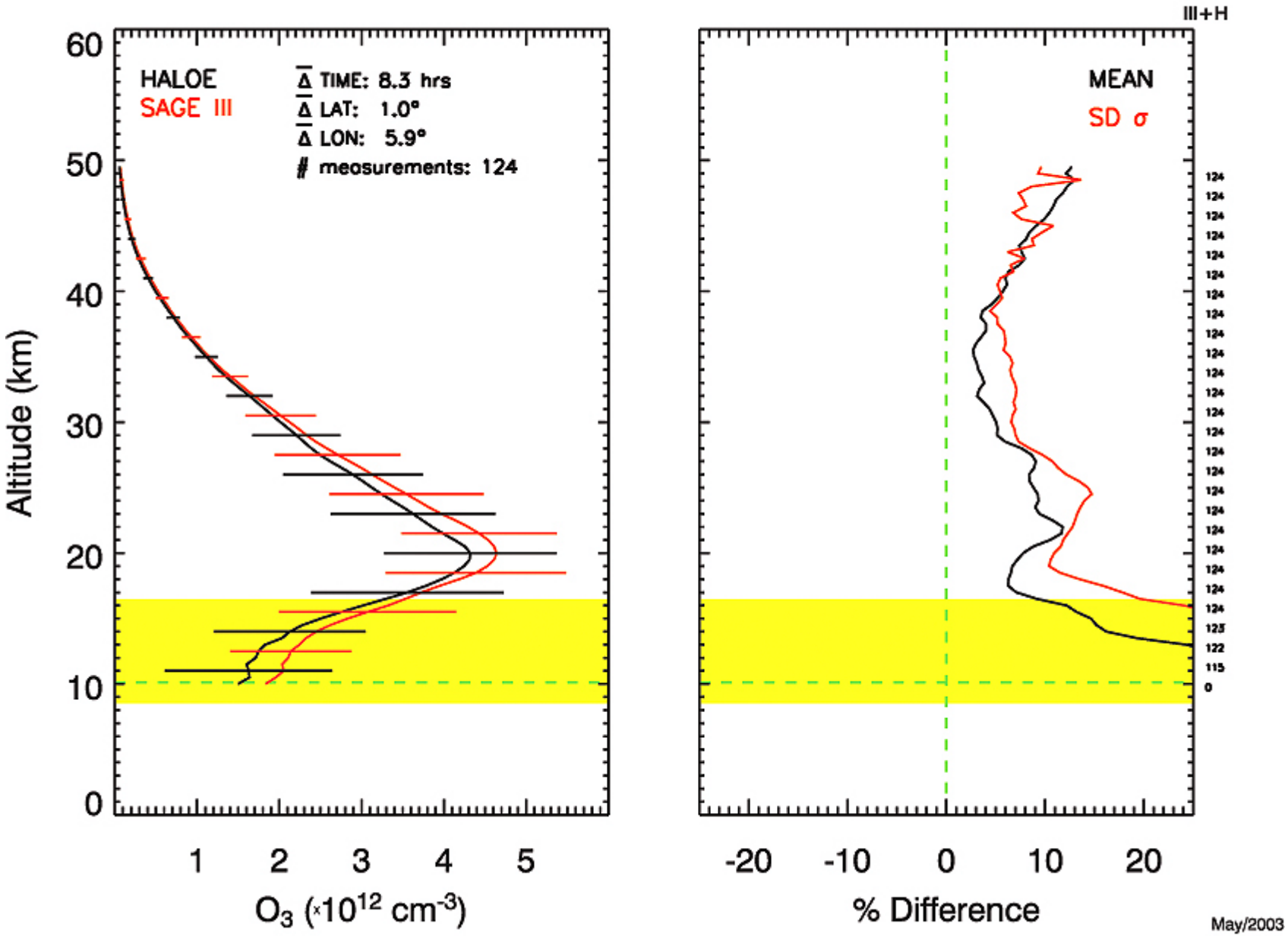
HALOE and SAGE III Comparisons


HALOE/SAGE III Coverage for 2002-2003
90
60
30
0
-30
-60
-90
Latitude
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar
Month
HALOE Sunrise
HALOE Sunset
SAGE III Sunrise
SAGE III Sunset
Apr/2003
19.0
2.00

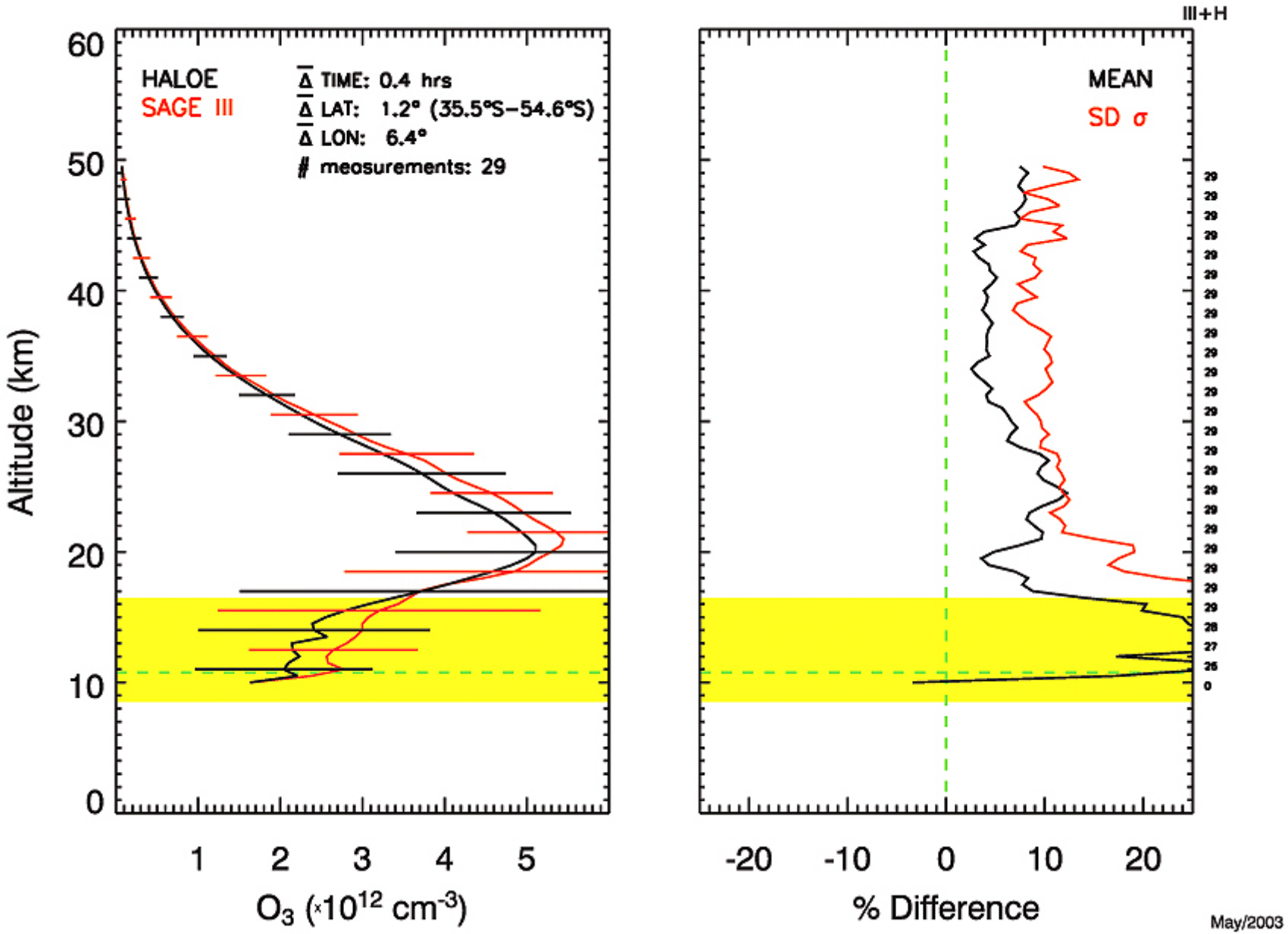
HALOE/SAGE III O_3 Comparisons (May-Feb)



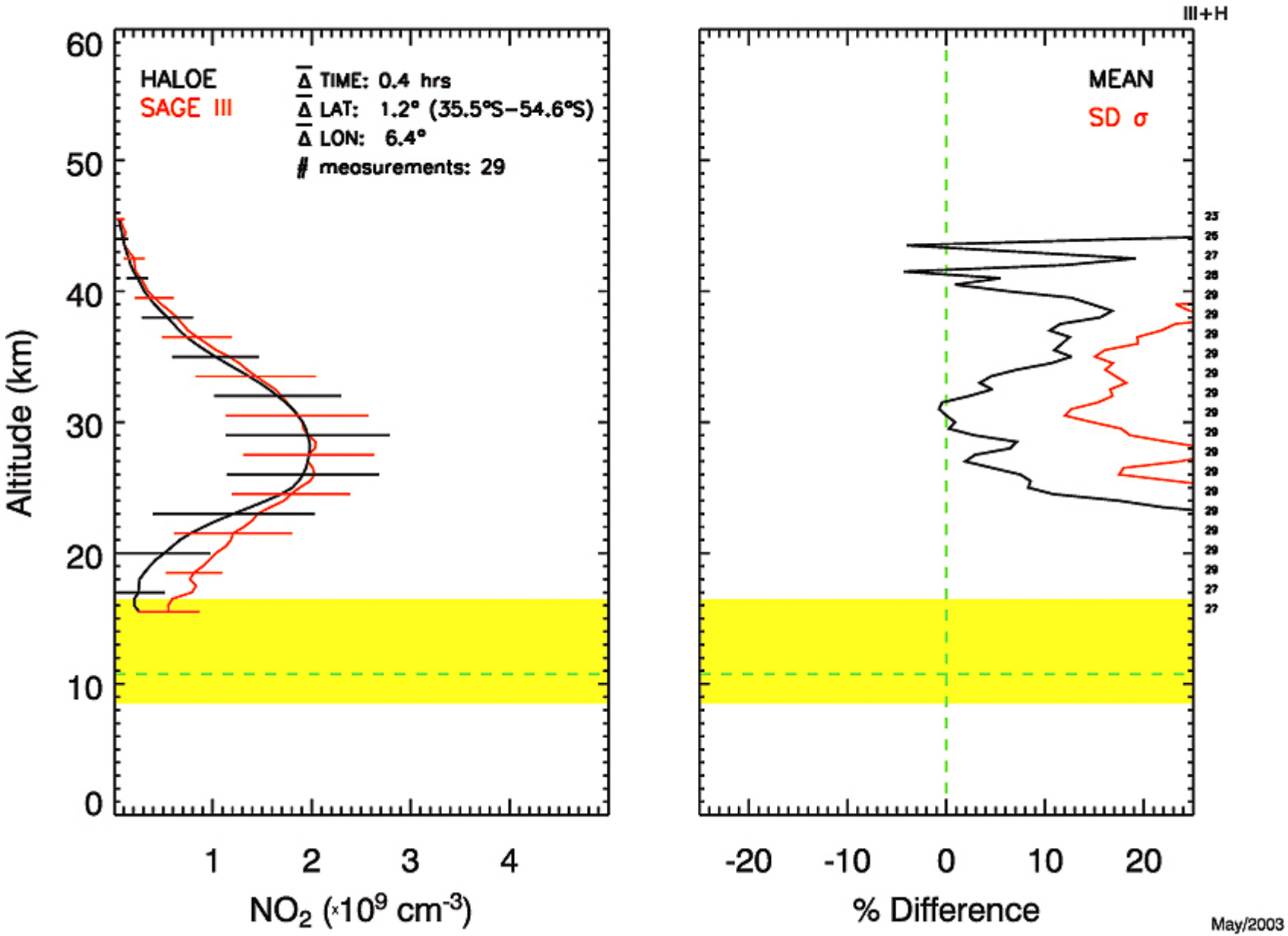
Composite of HALOE/SAGE III O_3 Comparisons (May-Feb)



HALOE/SAGE III SS O_3 Comparisons (May-Feb)

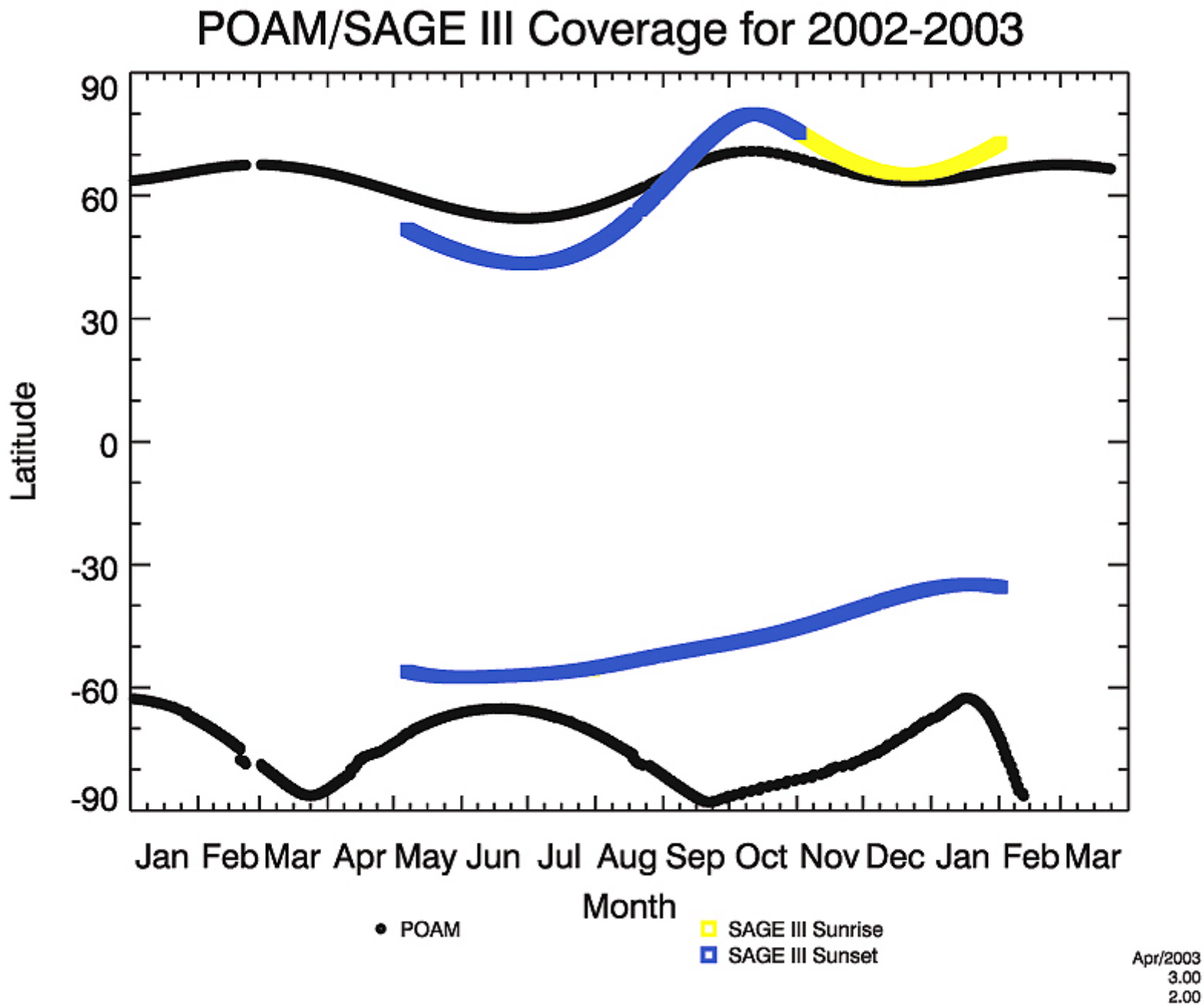


HALOE/SAGE III SS NO_2 Comparisons (May-Feb)

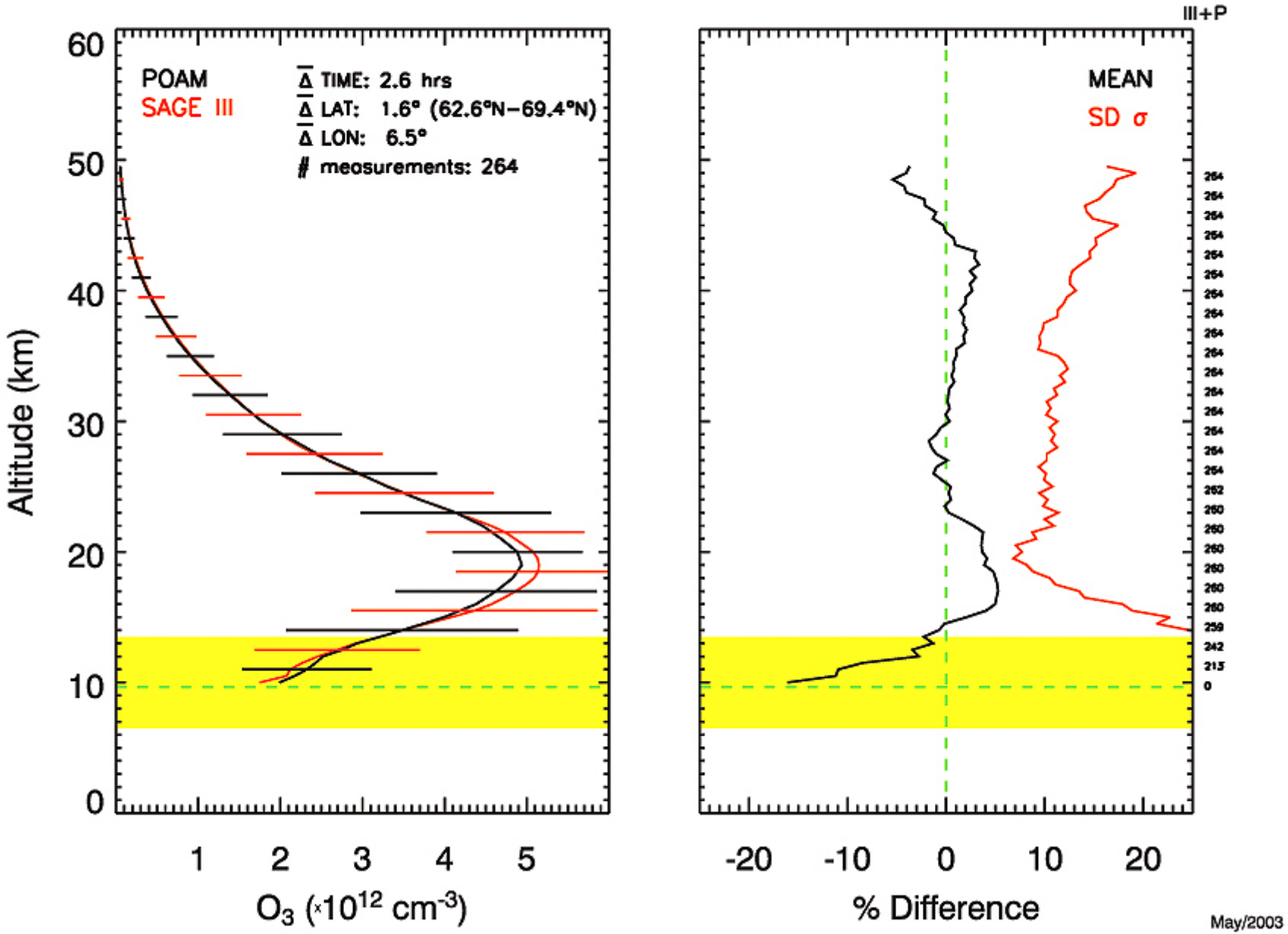


Validation

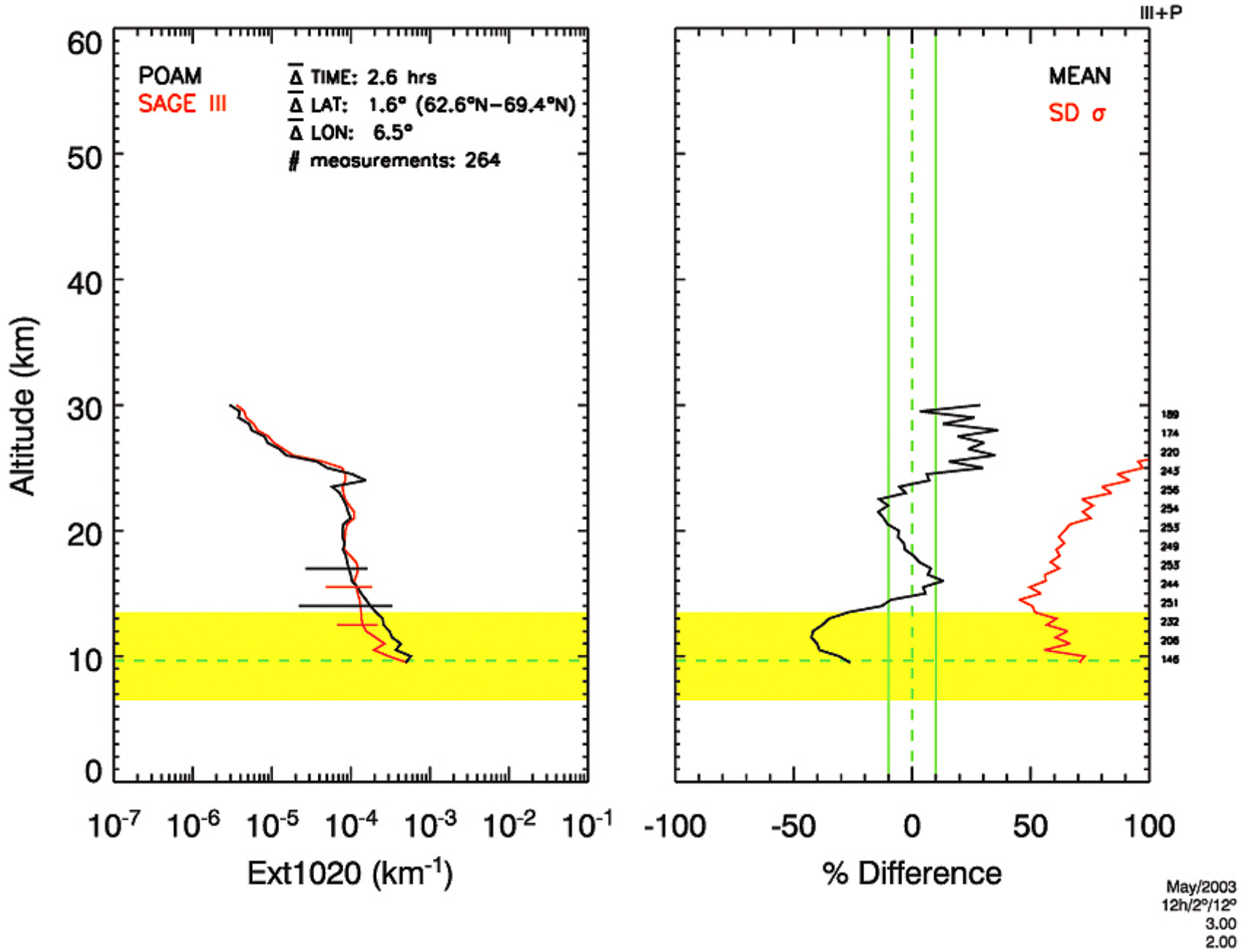
POAM and SAGE III Comparisons


POAM/SAGE III Coverage for 2002-2003
90
60
30
0
-30
-60
-90
Latitude
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar
Month
POAM
SAGE III Sunrise
SAGE III Sunset
Apr/2003
3.00
2.00

Composite of POAM/SAGE III O_3 Comparisons (May-Feb)



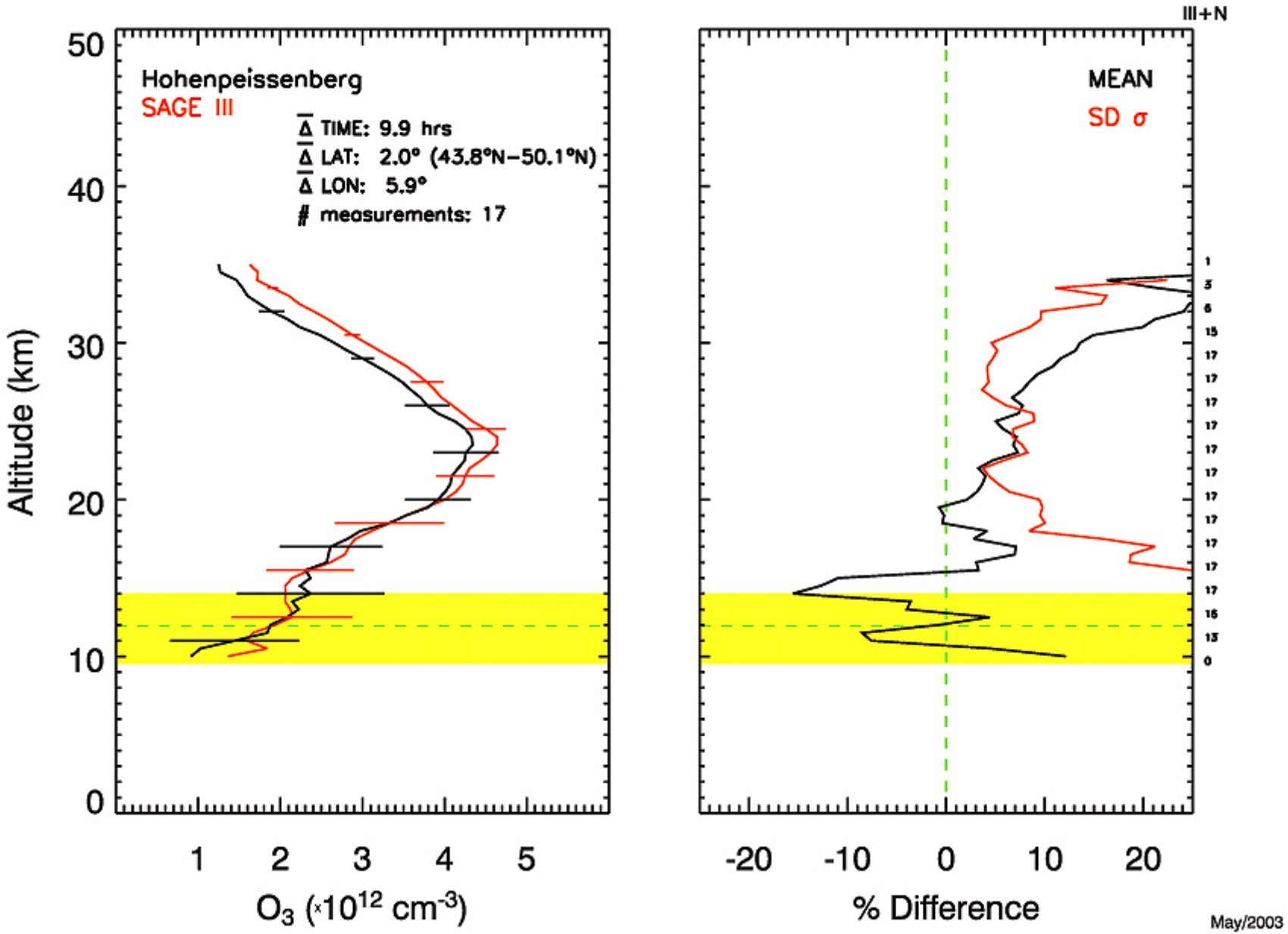
Composite of POAM/SAGE III Ext1020 Comparisons (May-Feb)



Validation

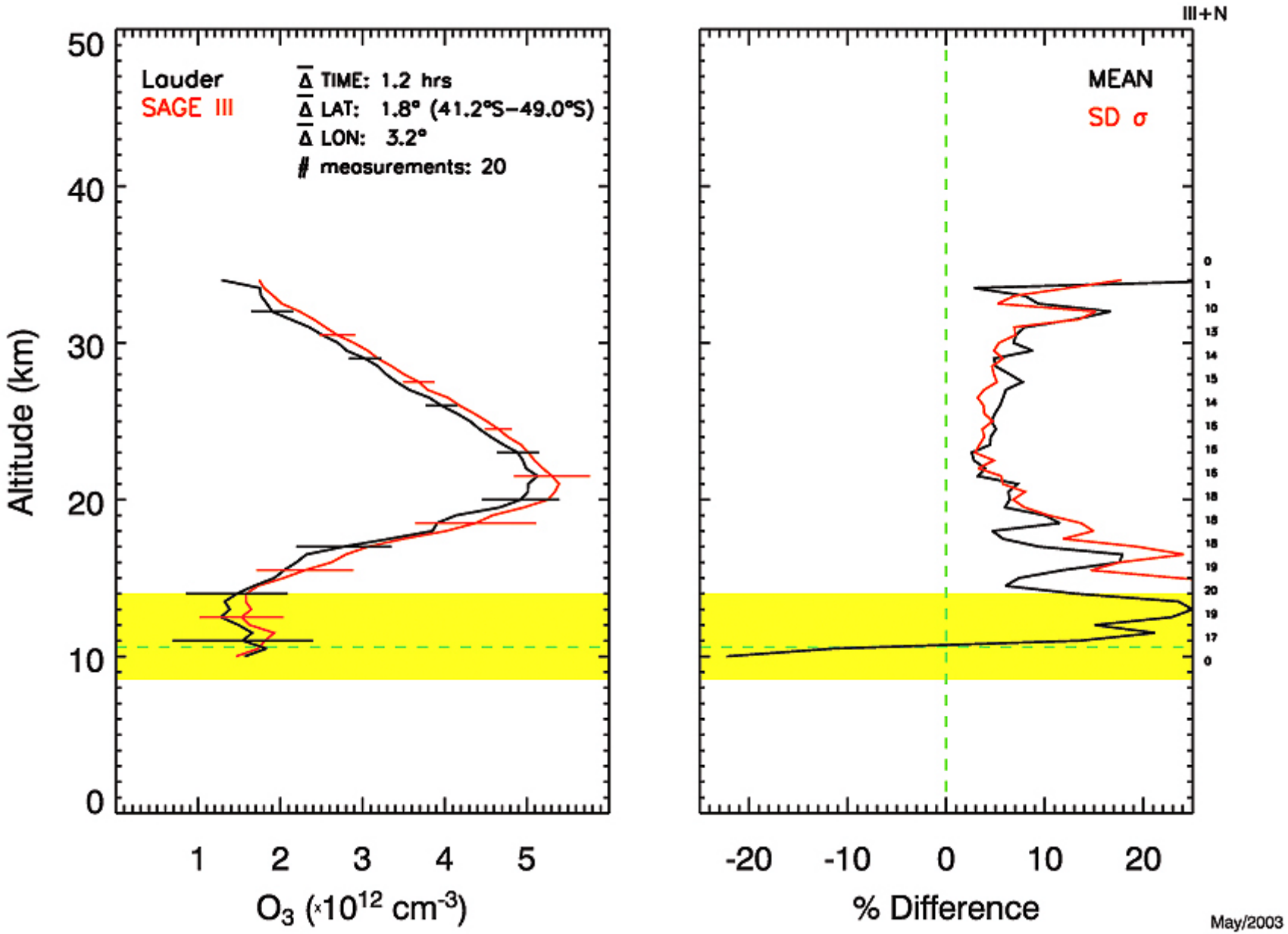
SONDE and SAGE III Comparisons

Composite of SONDE/SAGE III O_3 Comparisons (May-Feb)

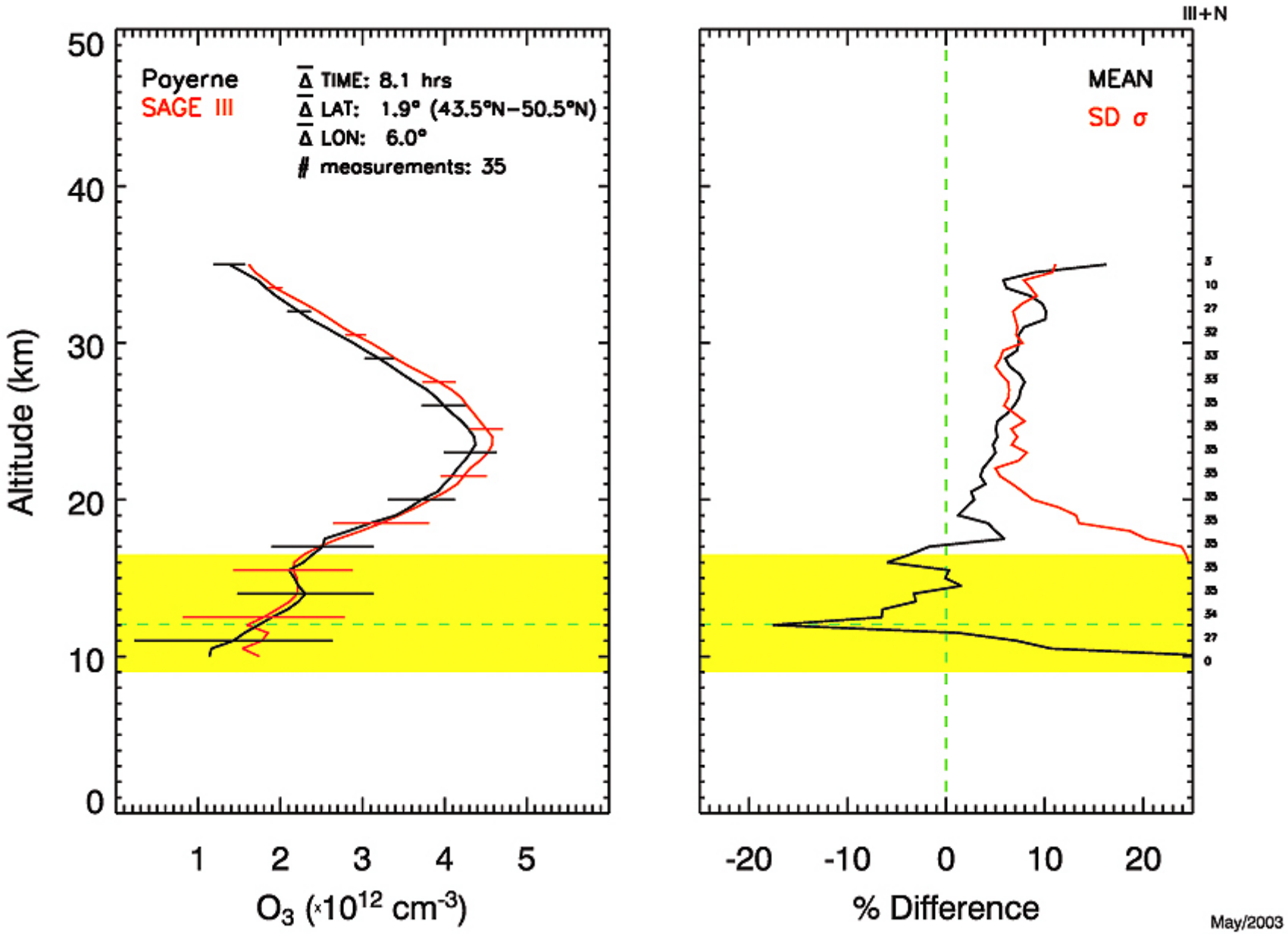


May/2003
12h/4°/12°
47.8°N/11.02°E
2.00

Composite of SONDE/SAGE III O_3 Comparisons (May-Feb)



Composite of SONDE/SAGE III O_3 Comparisons (May-Feb)

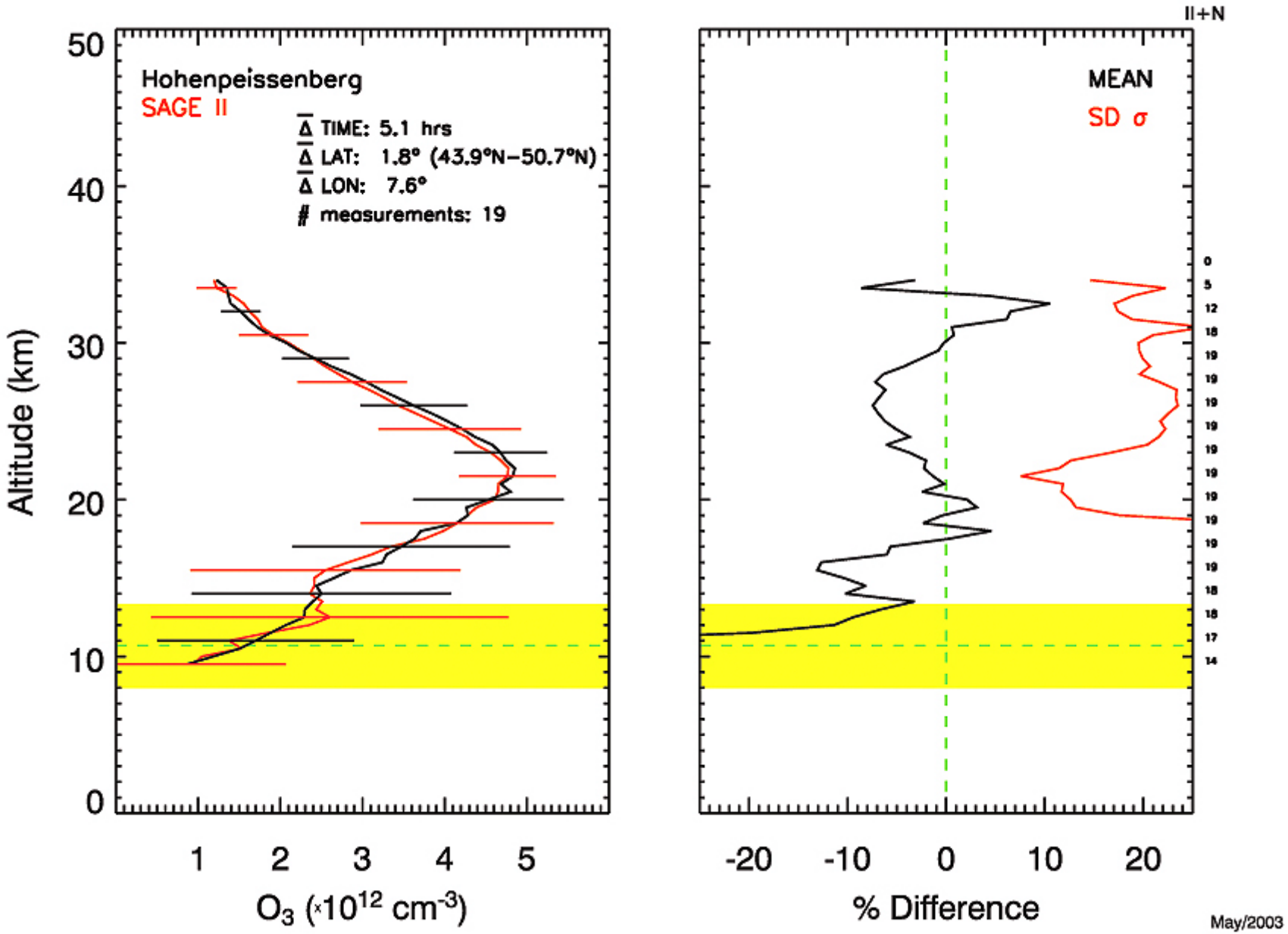


Validation

SONDE and SAGE II

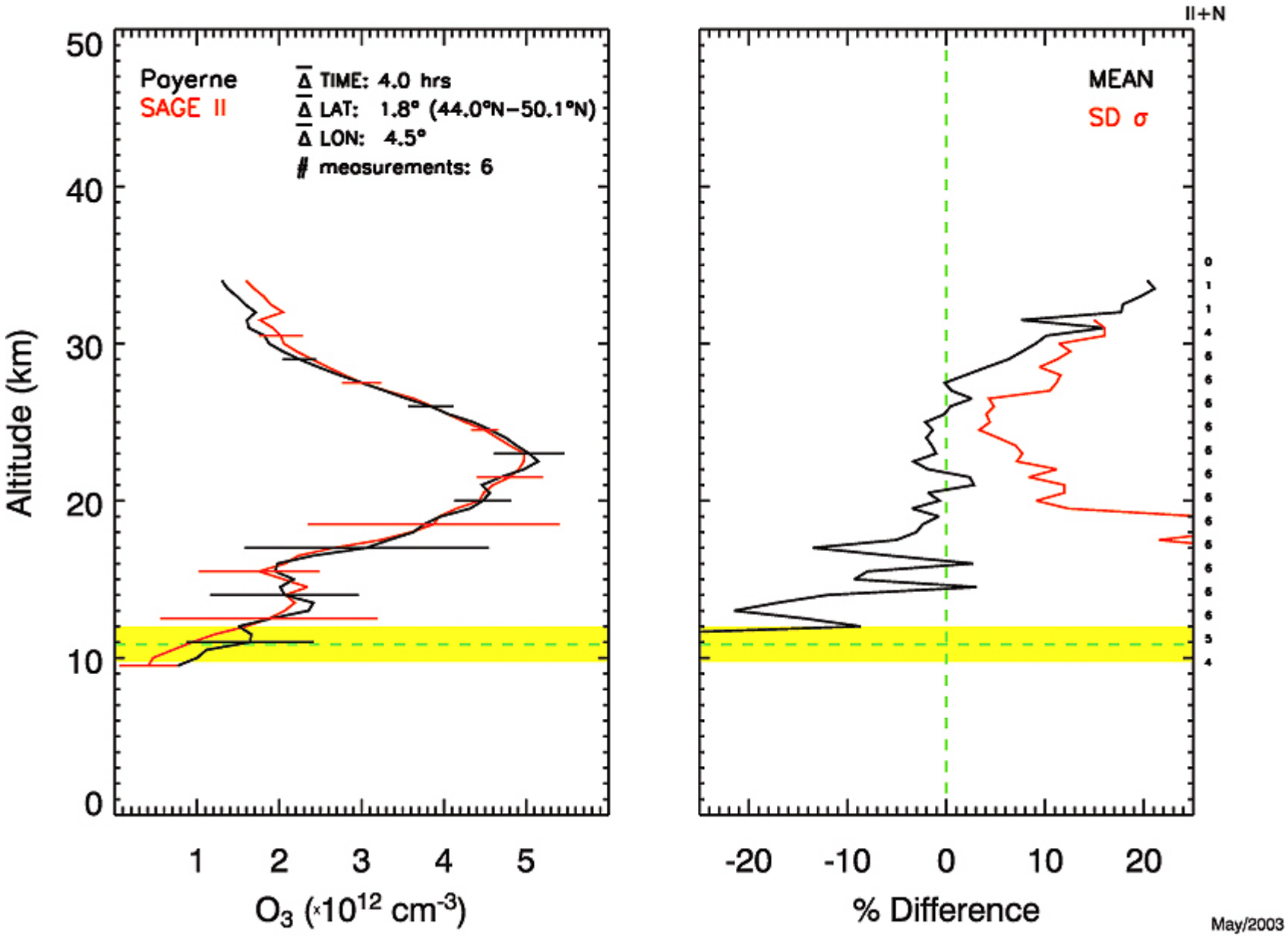
Comparisons

Composite of SONDE/SAGE II O_3 Comparisons (2002-2003)



May/2003
12h/4°/12°
47.8°N/11.02°E
6.10

Composite of SONDE/SAGE II O_3 Comparisons (2002-2003)

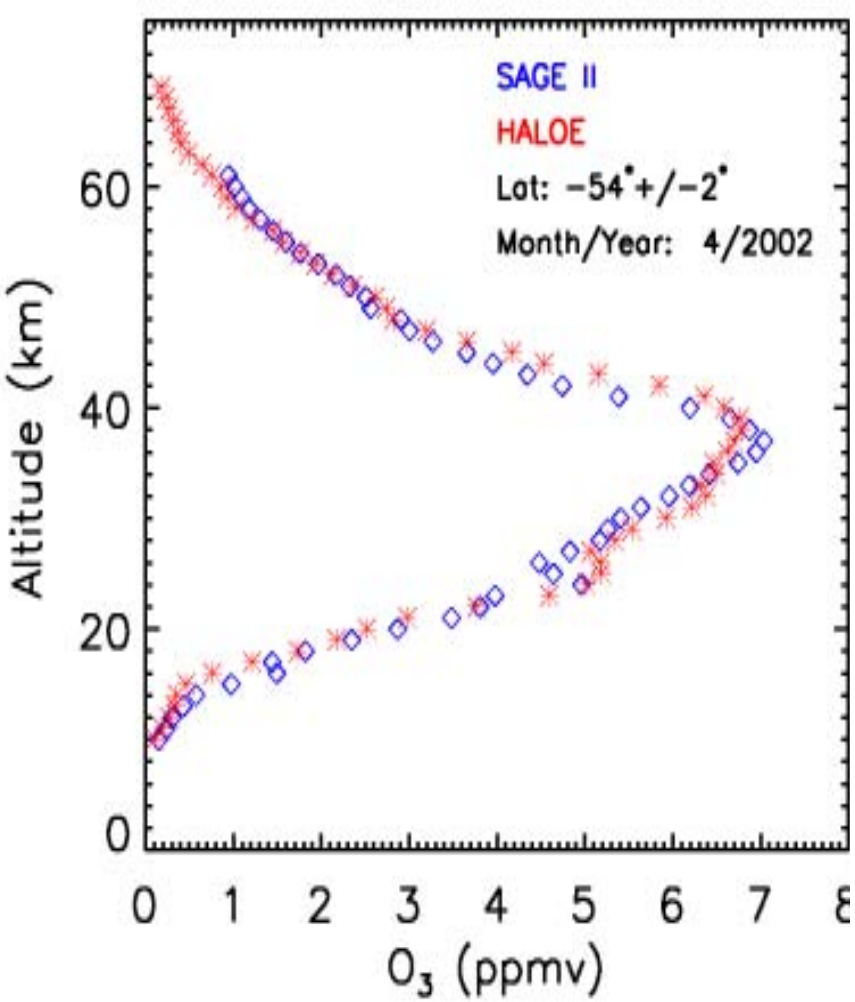


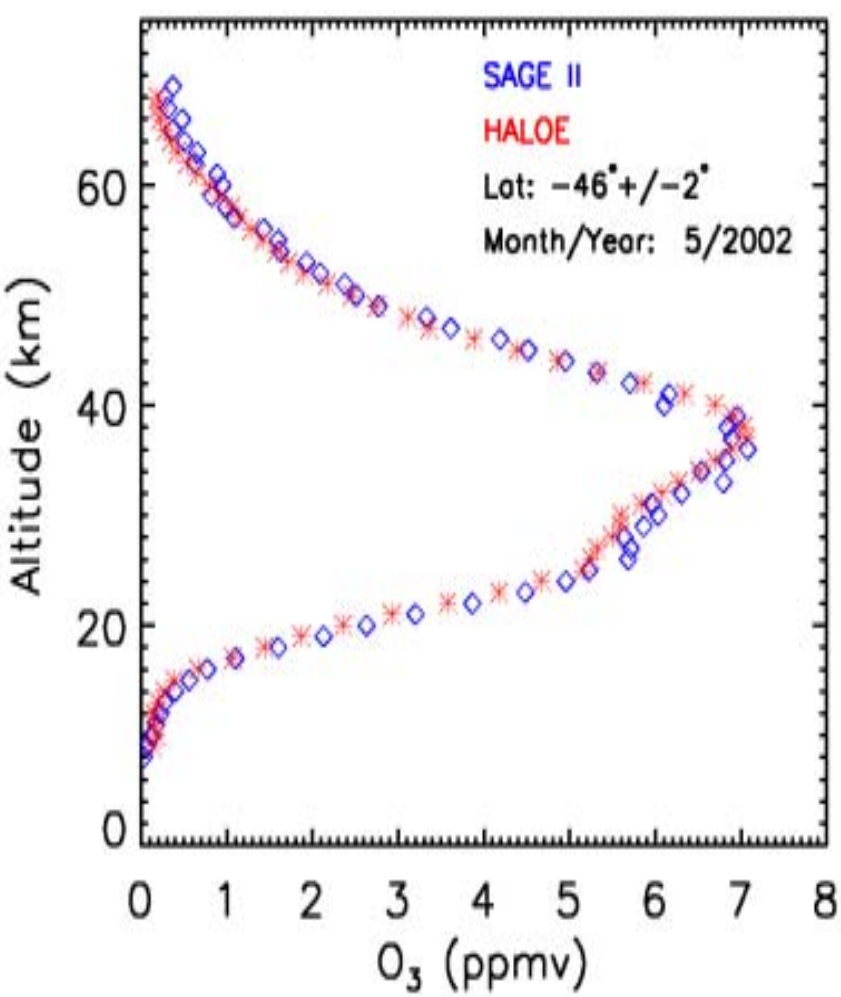
May/2003
12h/4°/12°
46.49°N/6.57°E
6.10

SAGE II AND HALOE COMPARISONS

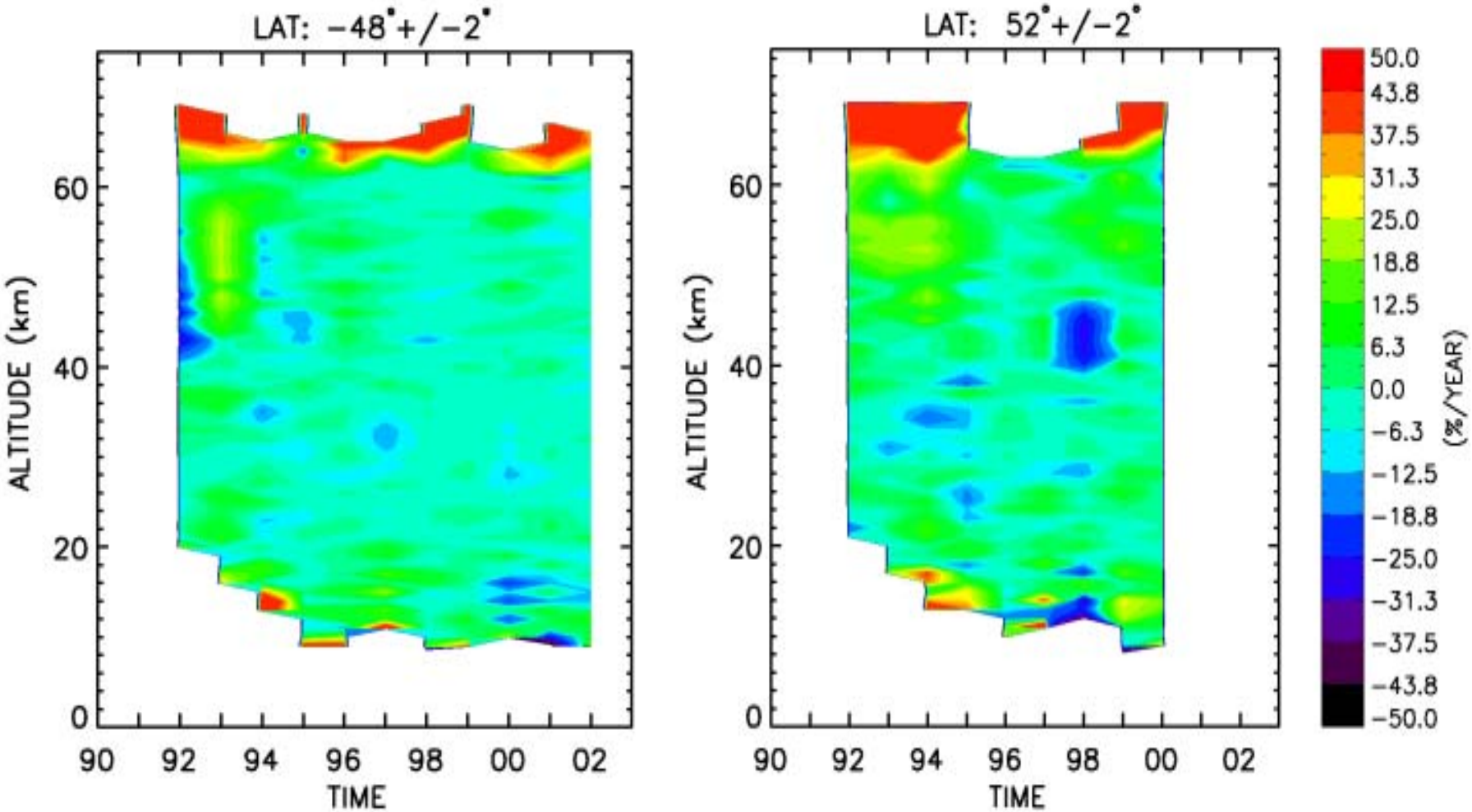
- Ozone data of s*unset and sunrise* events from the two instruments are compared at coincident points.
- In each latitude bin = 4°, profiles from SAGE II and HALOE were matched using coincidence criteria: Δ *latitude* < 2°, Δ *longitude* < 12°, *time* < 24 hours.
- The percent differences were calculated using the average of SAGE II and HALOE as a reference.
- *Weighted zonal means* of differences of combined data are calculated for the period from 1991 to 2002.

SAGE II AND HALOE MONTHLY WEIGHTED MEAN PROFILES





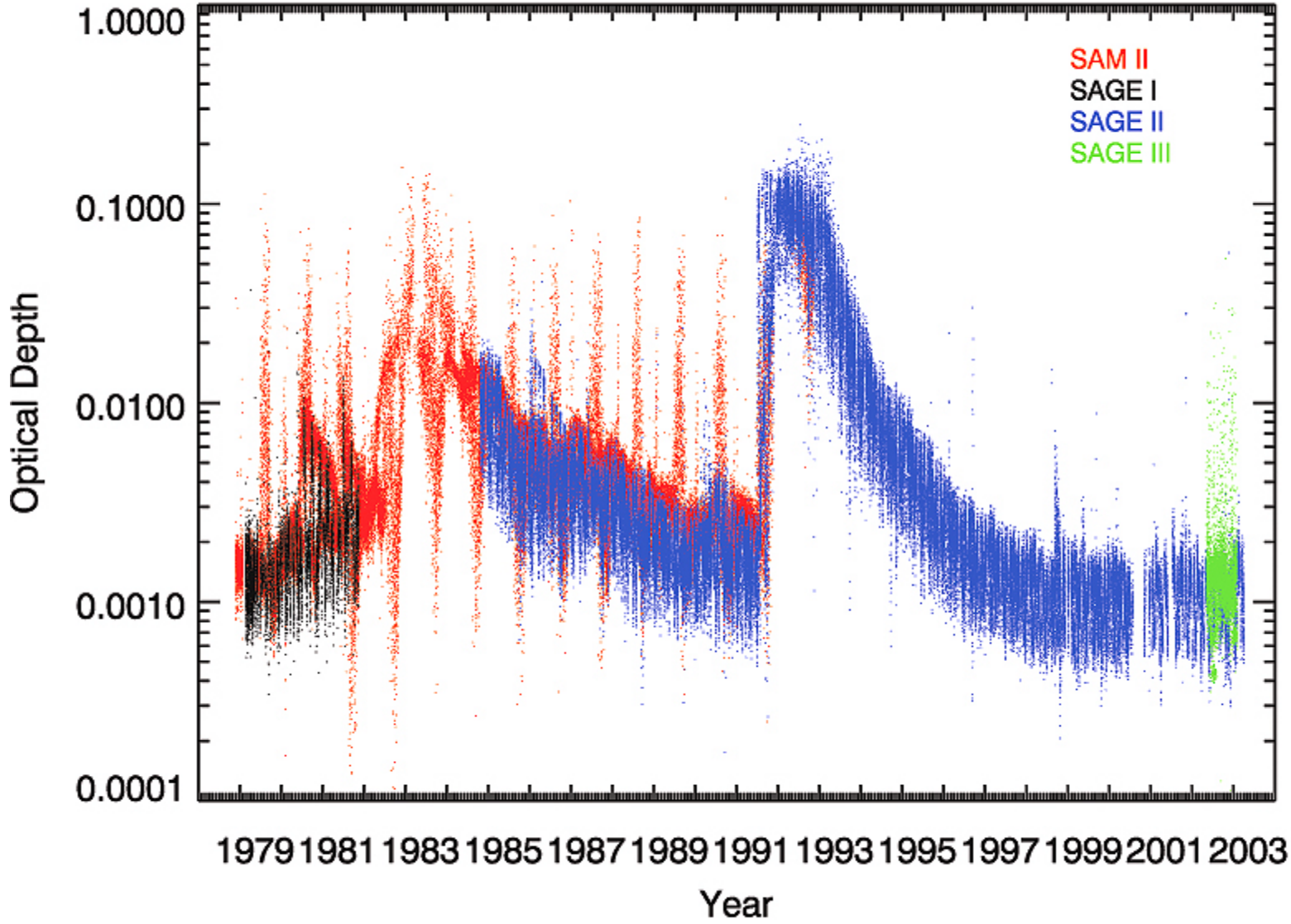
SAGE II – HALOE WEIGHTED MEAN PERCENT DIFFERENCE (Period 10/1991 – 10/2002)



Climatology

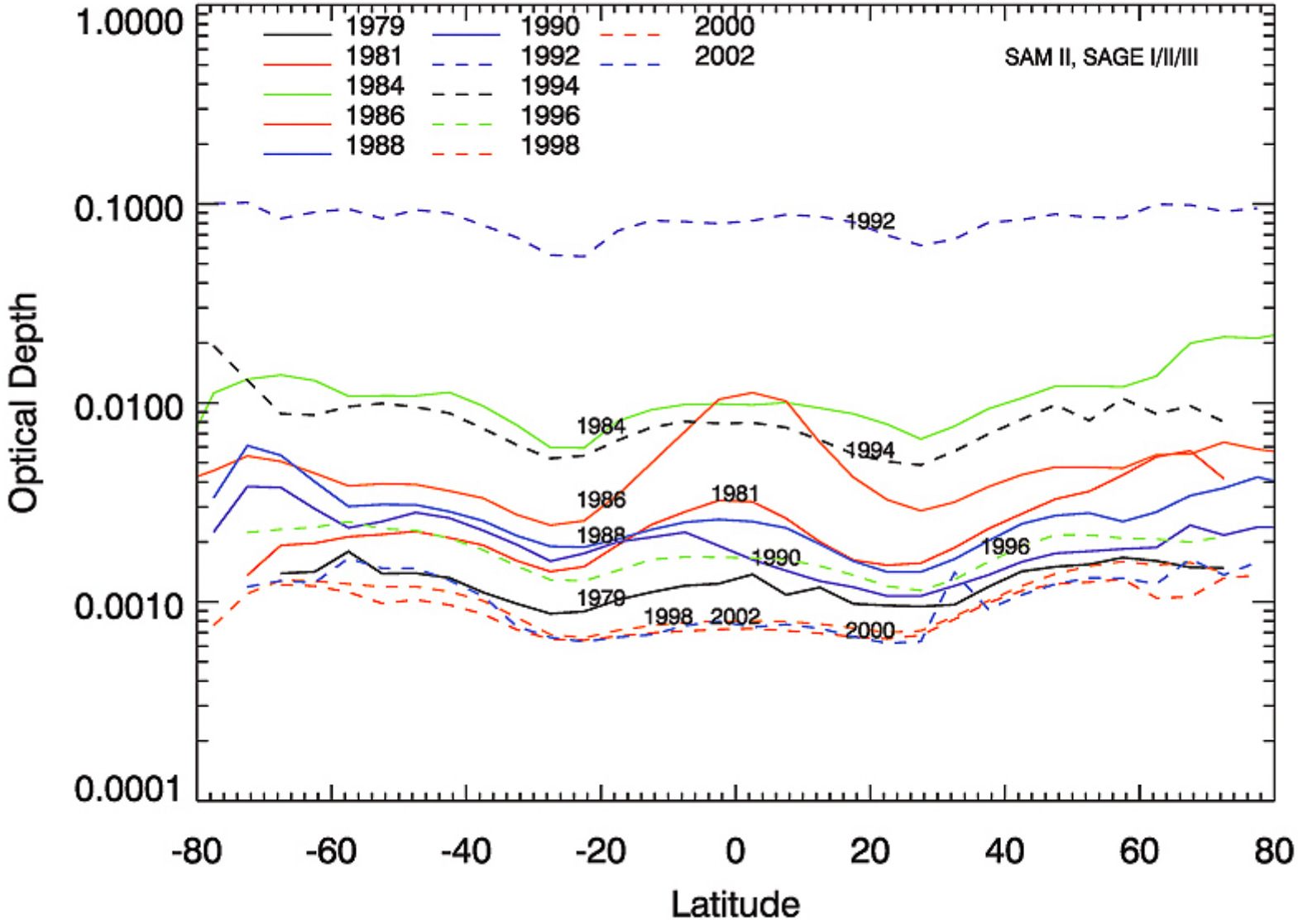
SAGE II Aerosols

Stratospheric Optical Depth



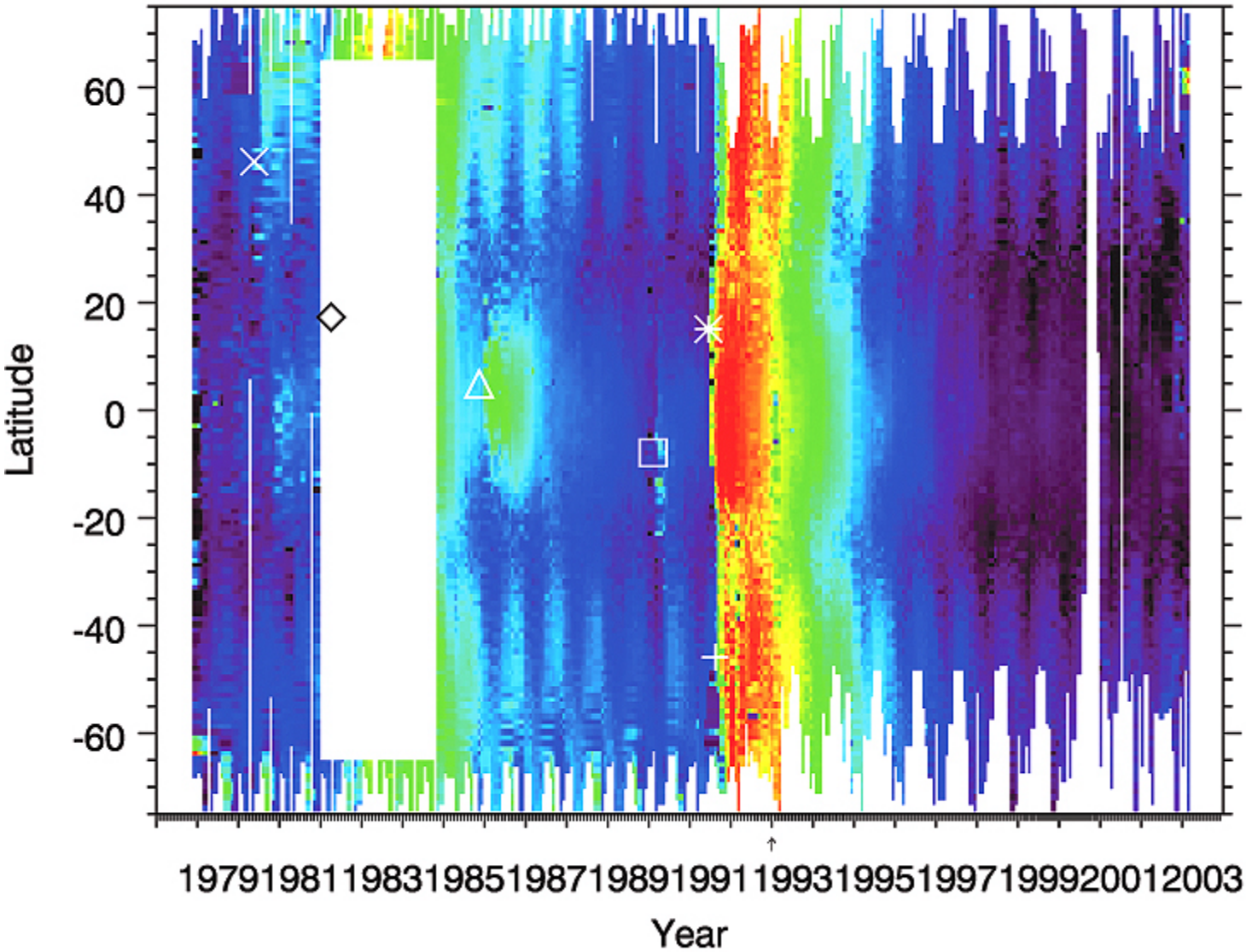
May/2003
6.10
2.00
T+2

Stratospheric Optical Depth
Zonal Means

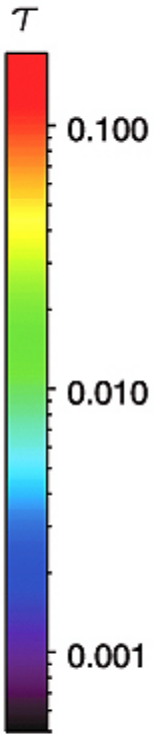


May/2003
6.10
2.00
T+2

Stratospheric Optical Depth
Zonal Means



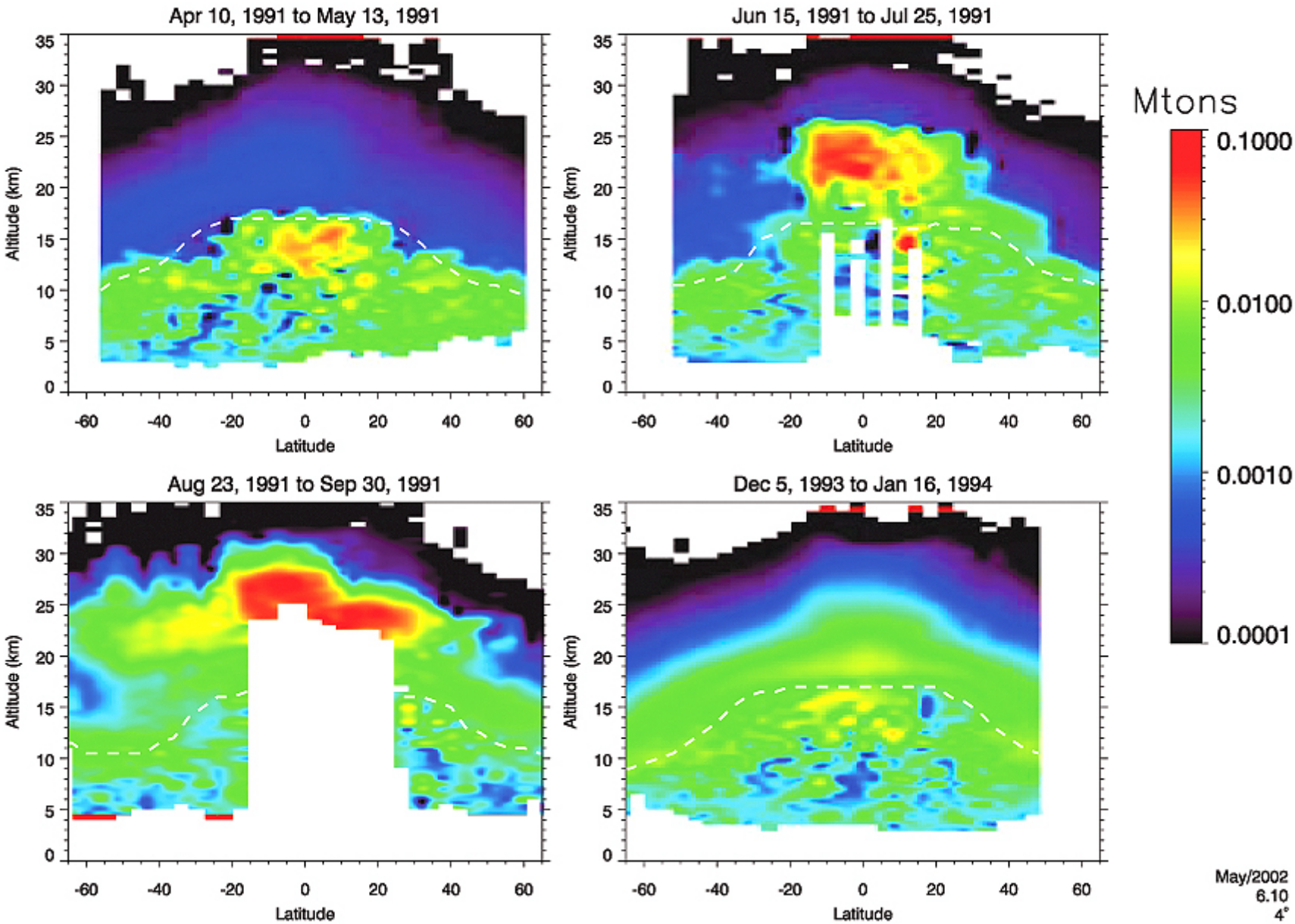
SAM II 10/78 - 12/92
SAGE I 2/79 - 6/81
SAGE II 10/84 - present
SAGE III 12/01 - present



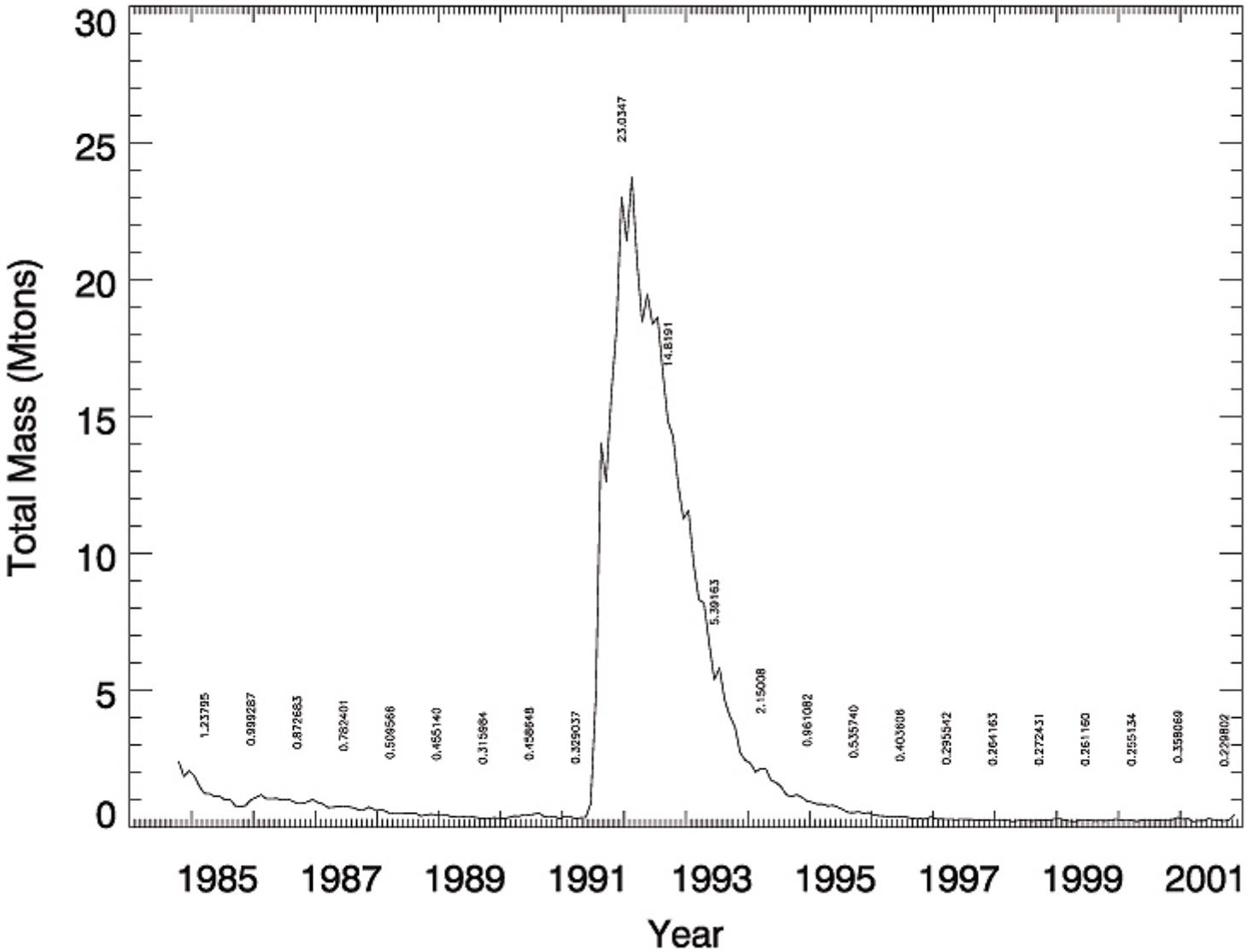
△ Ruiz
□ Kelut
✳ Pinatubo
+ Hudson
× St. Helens
◇ El Chichon

May/2003
6.10
2.00
T+2

Zonal Mass
Before and After 6/15/91 Pinatubo Eruption



Global Monthly Mass Loading in the Stratosphere
SAGE II



May/2002
6.10
T+2

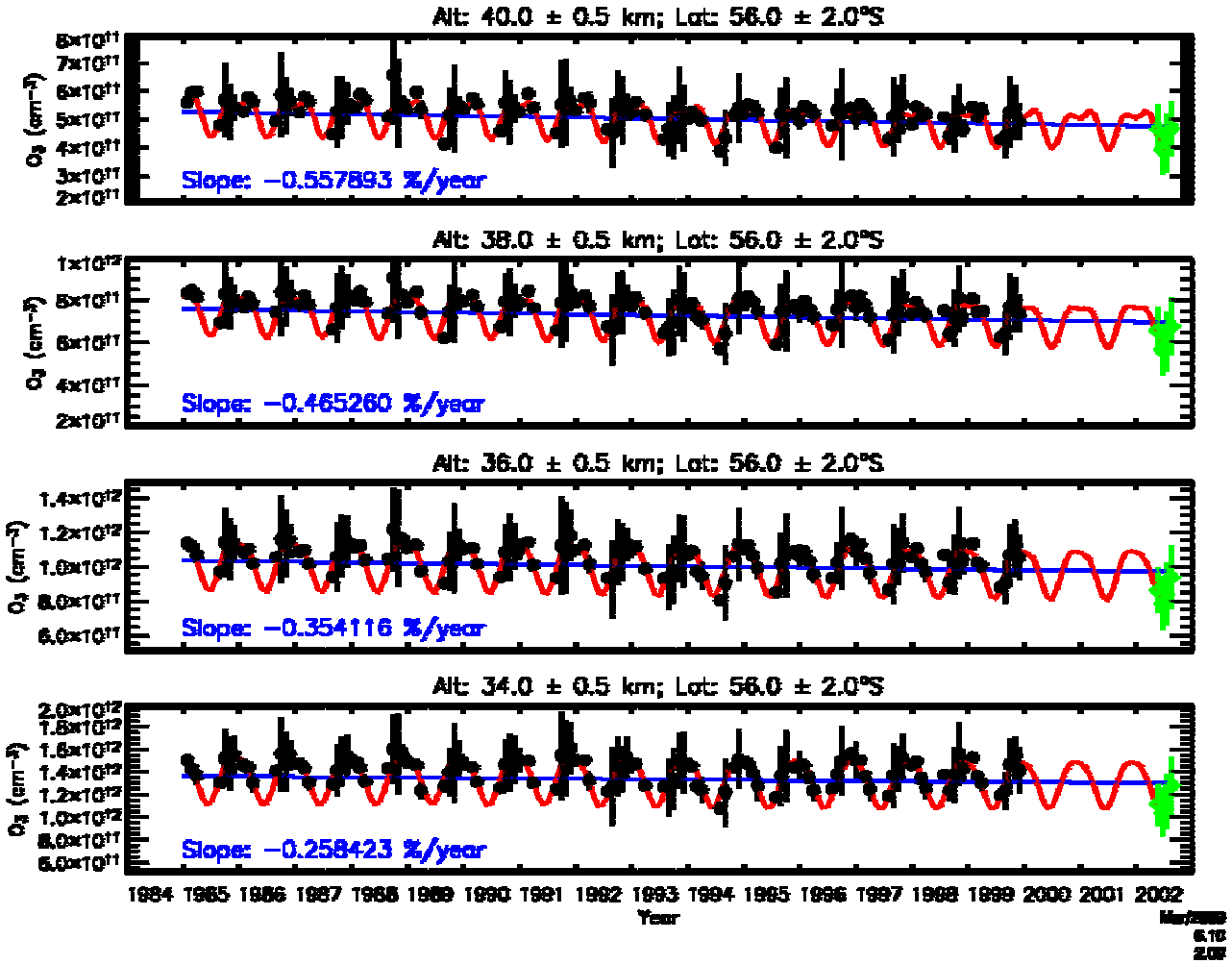
Climatology

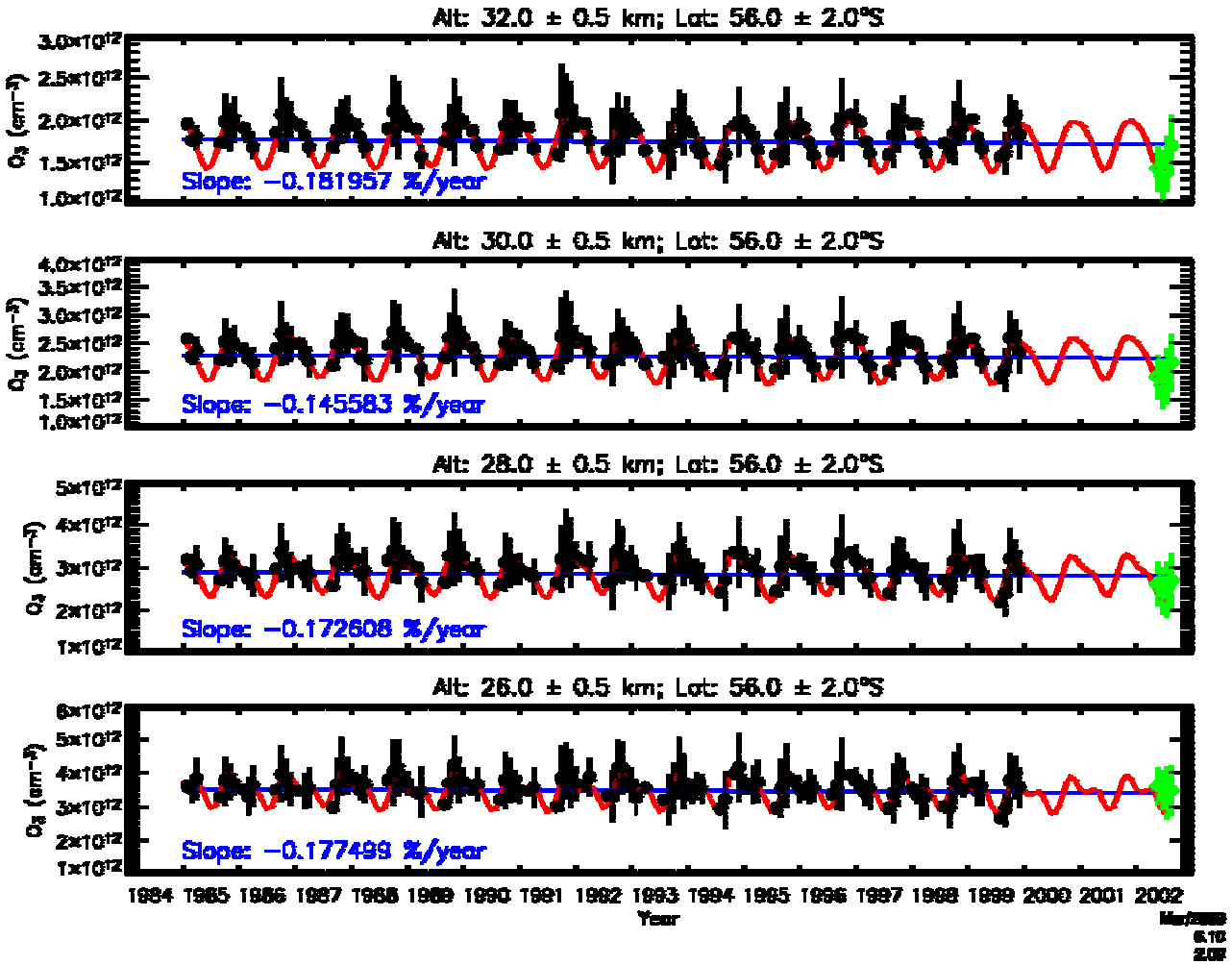
Ozone Time Series and Trends

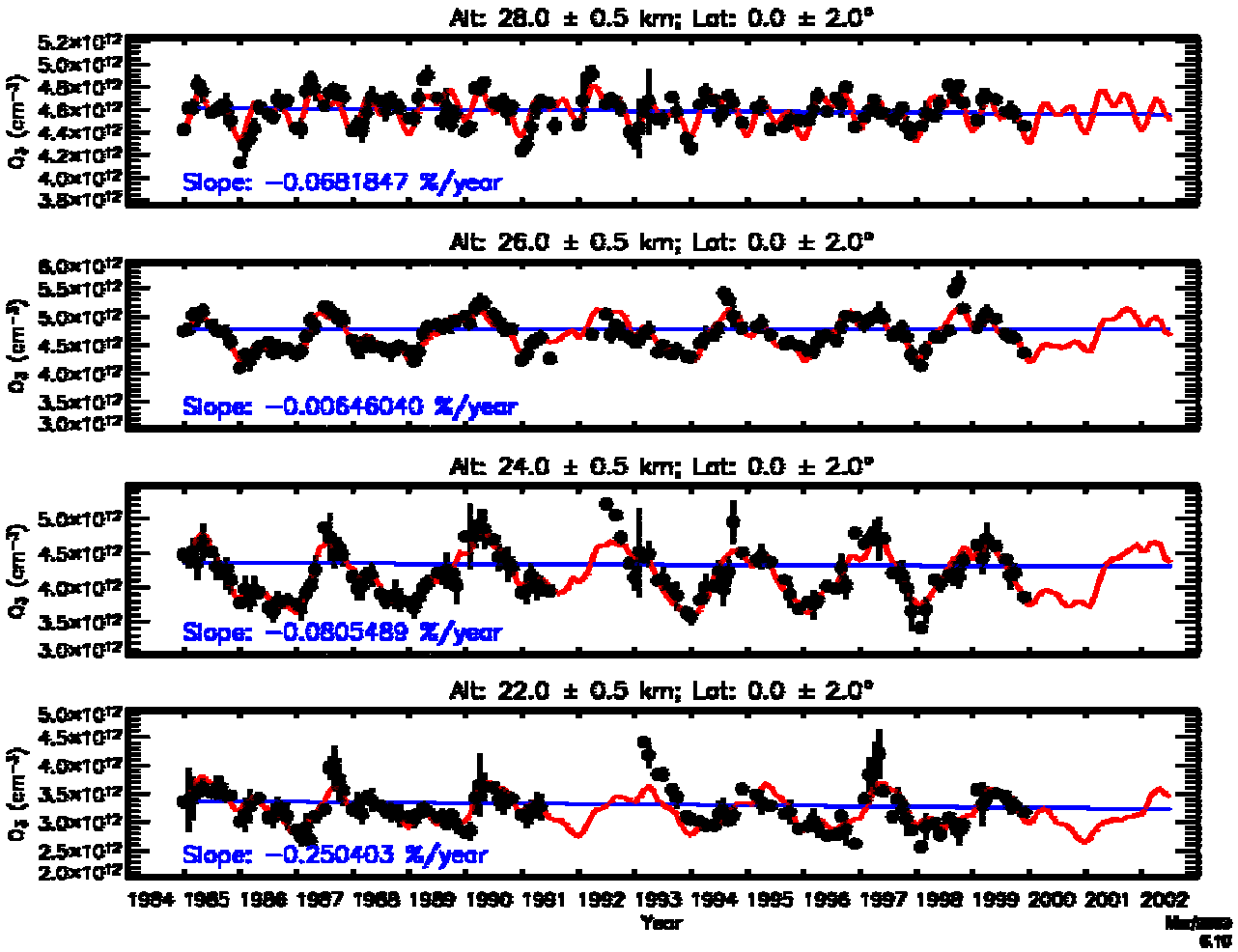
Model

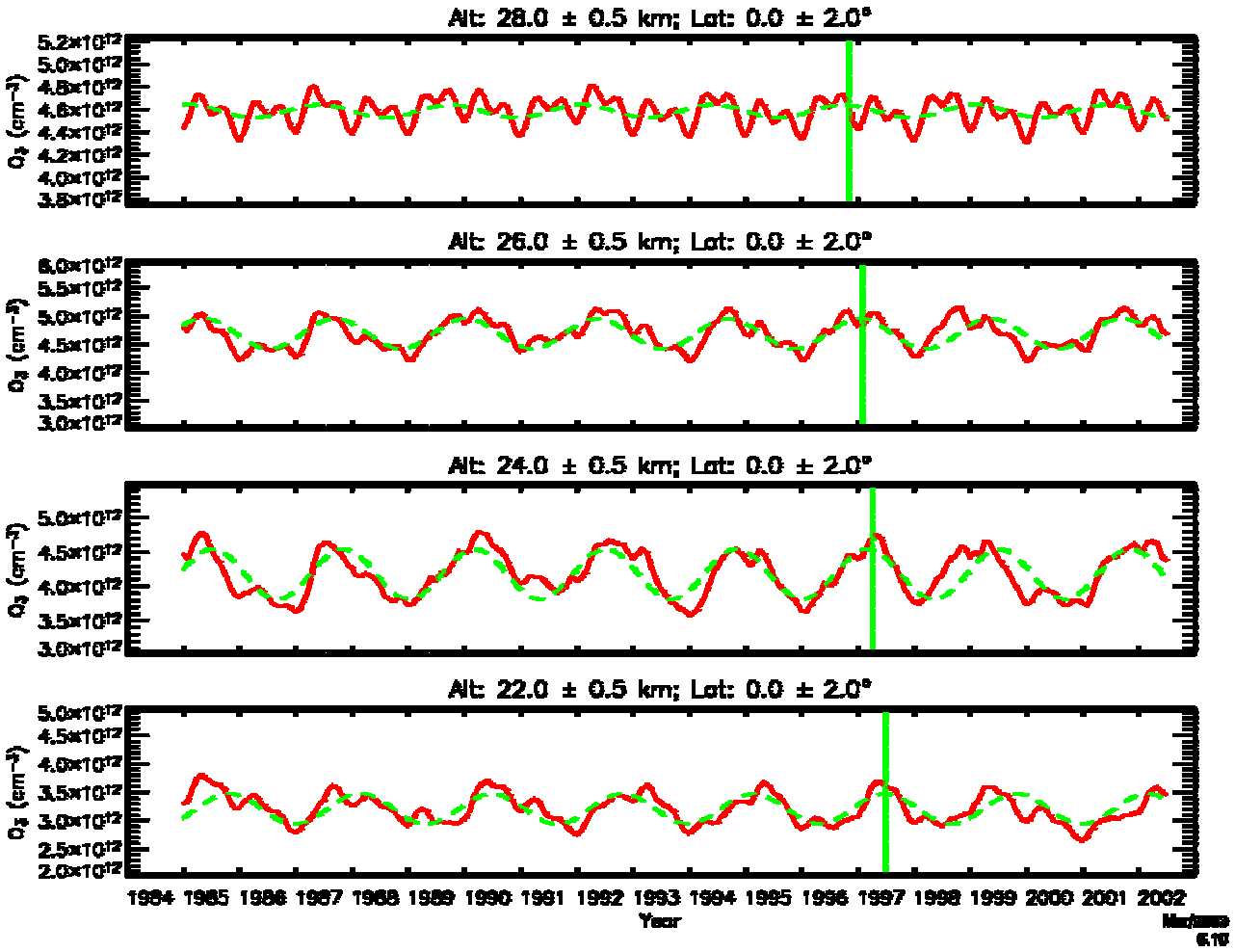
$$O_3 = mean + trend + seasonal + semiannual$$
$$+ QBO + solar + error$$

$$y_i = a_0 + a_1 t_i + a_2 \cos(2\pi t_i) + a_3 \sin(2\pi t_i)$$
$$+ a_4 \cos(4\pi t_i) + a_5 \sin(4\pi t_i) + a_6 [QBO]_{0i}$$
$$+ a_7 [QBO]_{1i} + a_8 [solar]_i + error_i$$


Alt: 40.0 ± 0.5 km; Lat: 56.0 ± 2.0°S
Slope: −0.557893 %/year
Alt: 38.0 ± 0.5 km; Lat: 56.0 ± 2.0°S
Slope: −0.465260 %/year
Alt: 36.0 ± 0.5 km; Lat: 56.0 ± 2.0°S
Slope: −0.354116 %/year
Alt: 34.0 ± 0.5 km; Lat: 56.0 ± 2.0°S
Slope: −0.258423 %/year
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
Year


Alt: 32.0 ± 0.5 km; Lat: 56.0 ± 2.0°S
Slope: −0.181957 %/year
Alt: 30.0 ± 0.5 km; Lat: 56.0 ± 2.0°S
Slope: −0.145583 %/year
Alt: 28.0 ± 0.5 km; Lat: 56.0 ± 2.0°S
Slope: −0.172608 %/year
Alt: 26.0 ± 0.5 km; Lat: 56.0 ± 2.0°S
Slope: −0.177499 %/year
O_3 (cm^{-3})
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
Year


Alt: 28.0 ± 0.5 km; Lat: 0.0 ± 2.0°
Slope: −0.0681847 %/year
Alt: 26.0 ± 0.5 km; Lat: 0.0 ± 2.0°
Slope: −0.00646040 %/year
Alt: 24.0 ± 0.5 km; Lat: 0.0 ± 2.0°
Slope: −0.0805489 %/year
Alt: 22.0 ± 0.5 km; Lat: 0.0 ± 2.0°
Slope: −0.250403 %/year
O_3 (cm^{-3})
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
Year


Alt: 28.0 ± 0.5 km; Lat: 0.0 ± 2.0°
Alt: 26.0 ± 0.5 km; Lat: 0.0 ± 2.0°
Alt: 24.0 ± 0.5 km; Lat: 0.0 ± 2.0°
Alt: 22.0 ± 0.5 km; Lat: 0.0 ± 2.0°
O_3 (cm^{-3})
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
Year

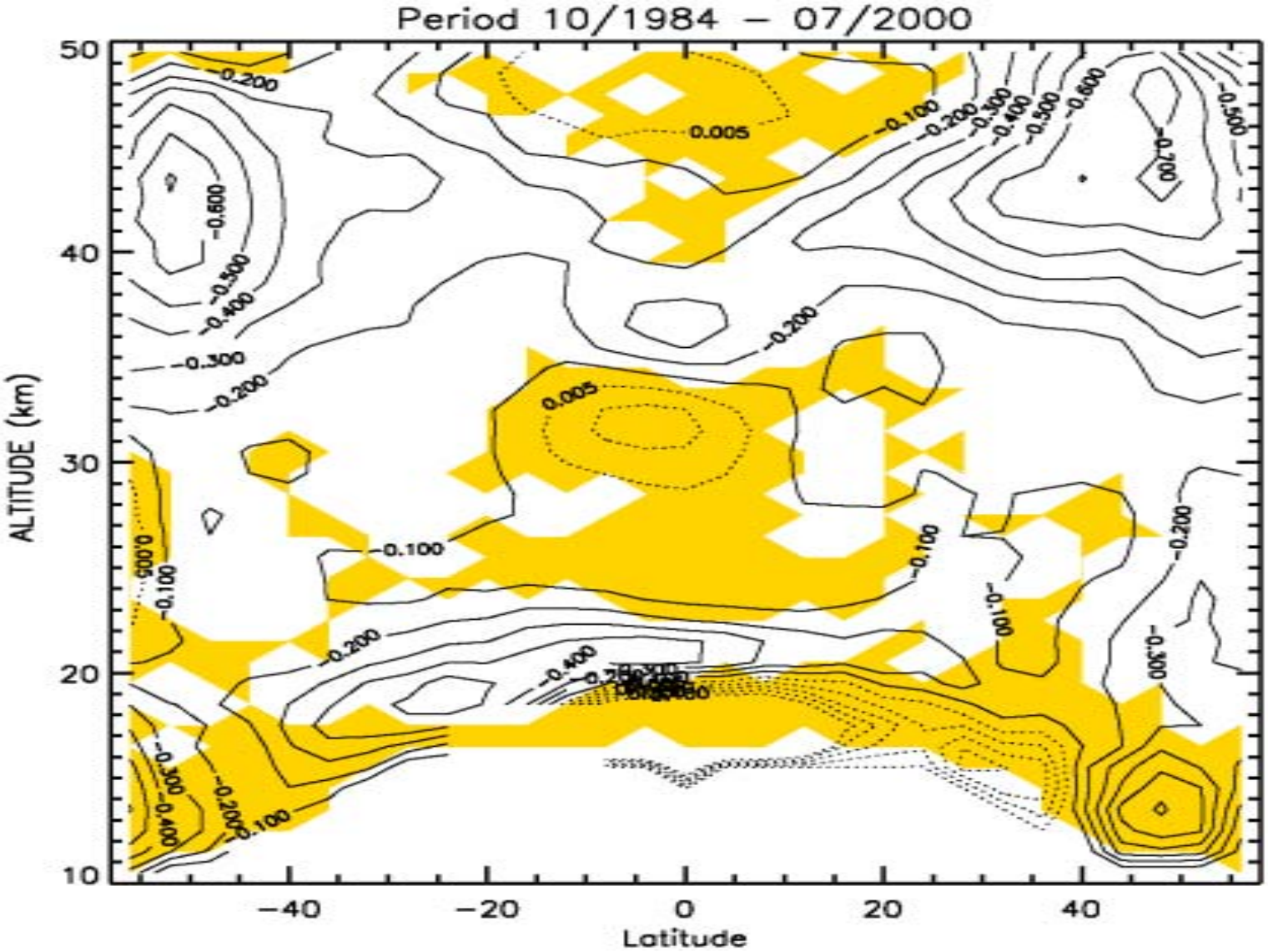
Model for Ozone Trends

- The model with mean, linear, annual, semi-annual, QBO, Solar, and autoregressive noise terms is fitted to the weighted monthly zonal averages , using Weighted Least Square Fit.

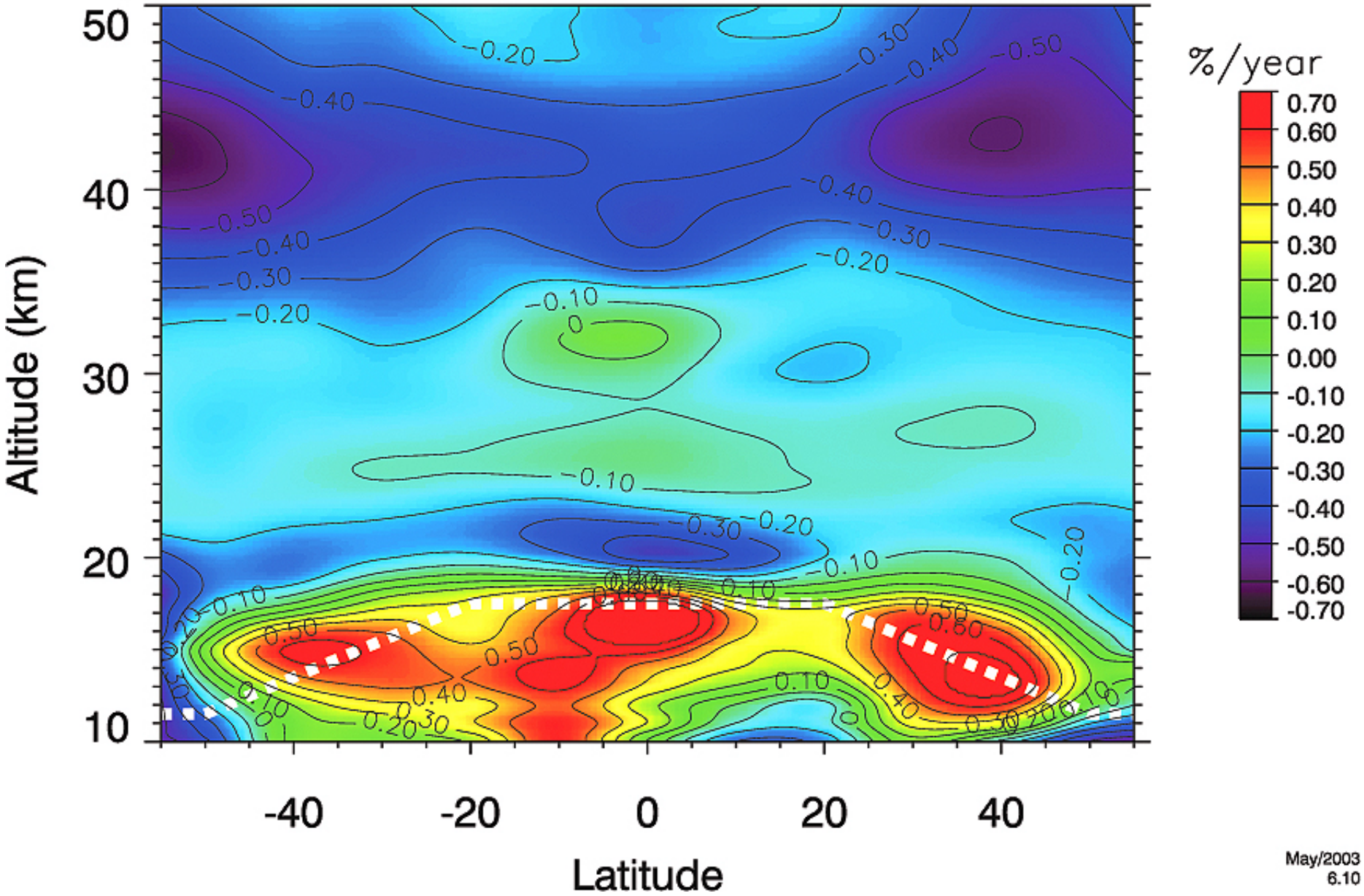
  $O_3(t)= b_o + b_1 t + b_2\cos(2\pi t) + b_3\sin(2\pi t) + b_4\cos(4\pi t) + b_5\sin(4\pi t) + QBO + Solar + Noise.$

- The Prais - Winsten method is used to account for autocorrelation.
- QBO is modeled applying the Principal Component Analysis to the Singapore Zonal Winds. The F10.7 flux is used for solar proxy.

SAGE II OZONE TRENDS



SAGE II O_3 Trends (1985-1999)



Future Work

- Validation
  - HALOE v20, SAGE II v6.2, and subsequent datasets
  - Comparisons with other instruments
  - Weighted comparisons of profiles
  - Compare profiles by potential vorticity
- Climatology/Trends
  - Create a unified climatology, including data from SAGE, HALOE, and ozonesondes
  - Average ozone by potential vorticity
  - Model the QBO using nonlinear principal component analysis