Balloon-borne DOAS measurements of SCIAMACHY Level 1 and 2 product

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Validated SCIAMACHY Products Level 1 and 2 by DOAS (1)

SCIAMACHY Products	Instrument	Precision	Accuracy	Validation Height Range	SCIAMACHY Height Range (ii)	IGOS target RMS error	IGOS target Bias error
T	all payloads	? 0.5 K	? 0.5 K	0 to 30/40 km	0 to 50 km	? 0.5K	n/s
P	all payloads	? 1 %	? 1 %	0 to 30/40 km	0 to50 km	n/s	n/s
O_3	DOAS	? 0.3 %	? 0.5 % 10^{10} molecule/cm^3	5 to 30/40 km	0 to 60 km	?3 %	?5 %
O_3	LPMA	? 4%	(? 4%,iv) , ? 6%	5 to 30/40 km	0 to 60 km	?3 %	?5 %
O_4	DOAS	? 4 %	? 4 %	5 to 30 km	0 to 25 km	n/s	n/s
NO_2 (i)	DOAS	? 2.0 %	<? 4.0 % ? 10^9 mole/cm^3	5 to 30/40 km	0 to 40 km	? 10 %	? 15 %
NO_2 (i)	LPMA	? 11.0 %	(? 6.0 %,iv), ? 12.5%	15 to 30/40 km	0 to 40 km	? 10 %	? 15 %
NO_3 (i)	DOAS		? 12.0 %	5 to 30/40 km	20 to 40 km	? 10 %	? 15 %
BrO (i)	DOAS	? 4.0 %	? 12.0 % plus ?5*10^{12} mole/cm^3	5 to 30/40 km	15 to 35 km	? 80 % UT ? 40 % LT	? 15 %
OClO (i)	DOAS	? 3.0 %	? 8.0 %	5 to 30/40 km	15 to 35 km	n/s	n/s
CH_4	LPMA	? 7 %	(? 5 %,iv), ? 9 %	10 to 30/40 km	0 to 40 km	? 1% UT/ ? 2% LS	? 2% UT/ ? 5% LS
CO	LPMA	? 7 %	(? 2 %,iv), ? 8 %	5 to 30/40 km	0 to 35 km	? 1% UT/ ? 5% LS	? 2% UT/ ? 10% LS
N_2O	LPMA	?10	(? 3 %,iv), ? 11 %	5 to 30/40 km	0 to 40 km	? 1% UT/ ? 2% LS	? 2% UT/ ? 4% LS
CO_2	LPMA	? 5 %	(? 2 %,iv), ? 6 %	10 to 30/40 km	0 to 60 km	?0.04 ppm UT ?0.5 ppm LT	?0.2ppm,UT ?1.0 ppm LT

Validated SCIAMACHY Products Level 1 and 2 by DOAS (2):

1. direct solar irradiance within the 316 to 653 nm wavelength range

2. LIMB radiances perpendicular to the Sun‘s azimuth direction

3. NADIR radiance, the latter both parameters in the 320 to 550 nm wavelength range

Successful LPMA/DOAS Flights:

No	Date	Location	Geophysical Condition	Observation Mode
1	Nov. 23, 96	Leon, 42.6° N, 5.7° W	mid-latitude fall	sunset
2	Feb. 14, 97	Kiruna, 67.9°N, 21.1° E	high latitude winter	sunset
3	June 20, 97	Gap, 44.0° N, 6.1 ° E	mid-latitude summer	sunrise
4	March 19, 98	Leon, 42.6° N, 5.7° W	mid-latitude spring	sunset
5	Aug. 19/20, 98	Kiruna, 67.9°N, 21.1° E	high latitude summer	sunset/ sunrise
6	Feb. 10, 99	Kiruna, 67.9°N, 21.1° E	high latitude winter	sunset
7	June 25, 99	Gap, 44.0° N, 6.1 ° E	mid-latitude summer	sunrise
8	Feb. 18, 00	Kiruna, 67.9°N, 21.1° E	high latitude winter	sunset
9	Aug. 21/22, 01	Kiruna, 67.9°N, 21.1° E	high lat. summer	sunset/sunrise
10	March 23, 03	Kiruna, 67.9°N, 21.1° E	high lat. spring	sunset
11	Sept. 2003	Air sur l'Adour	mid-lat fall	sunset
12	March 04	Kiruna, 67.9°N, 21.1° E	high lat. spring	sunset
13	Fall 04	Teresina, 5.1° S, 42.8° W	tropical pipe	sunset/sunrise

previous, already conducted or scheduled within ENVISAT (SCIAMACHY, MIPAS, GOMOS) validation

DOAS Instruments on bord LPMA/DOAS

'Big'- DOAS instrument (direct Sun):

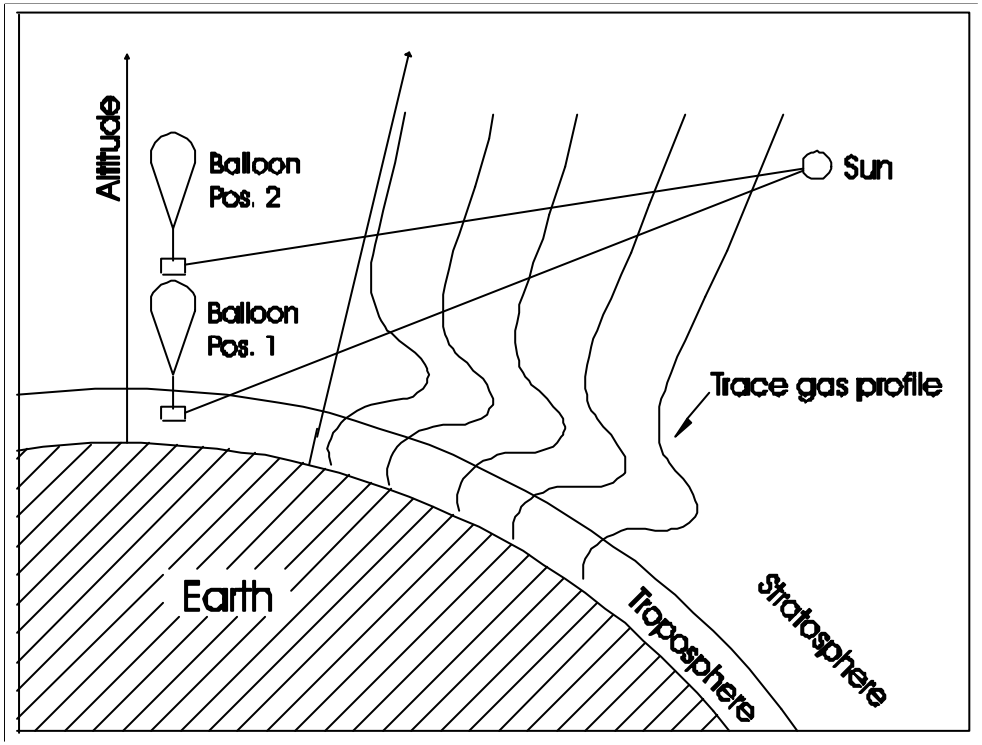
- 2 grating spectrometers in one thermostated (273 K) and evacuated housing
- Cooled photo diode detectors (1024 diodes, T = - 260 K)
- Wavelength ranges and resolution:
- UV (316 - 418 nm, ?? = 0.5 nm)
- Visible (418 - 653 nm, ?? = 1.3 nm)
- Light intake: Solar tracker and glas fibre bundle
- efficient spectrometer stray-light suppression
- Solar occultation
- Total mass 45 Kg
- Total power consumption ~20 W
- Target species: O3, O4, H2O, NO2, OClO, BrO, IO, OIO, and Mie extinction, solar irradiance

Mini-DOAS instruments (NADIR&LIMB):

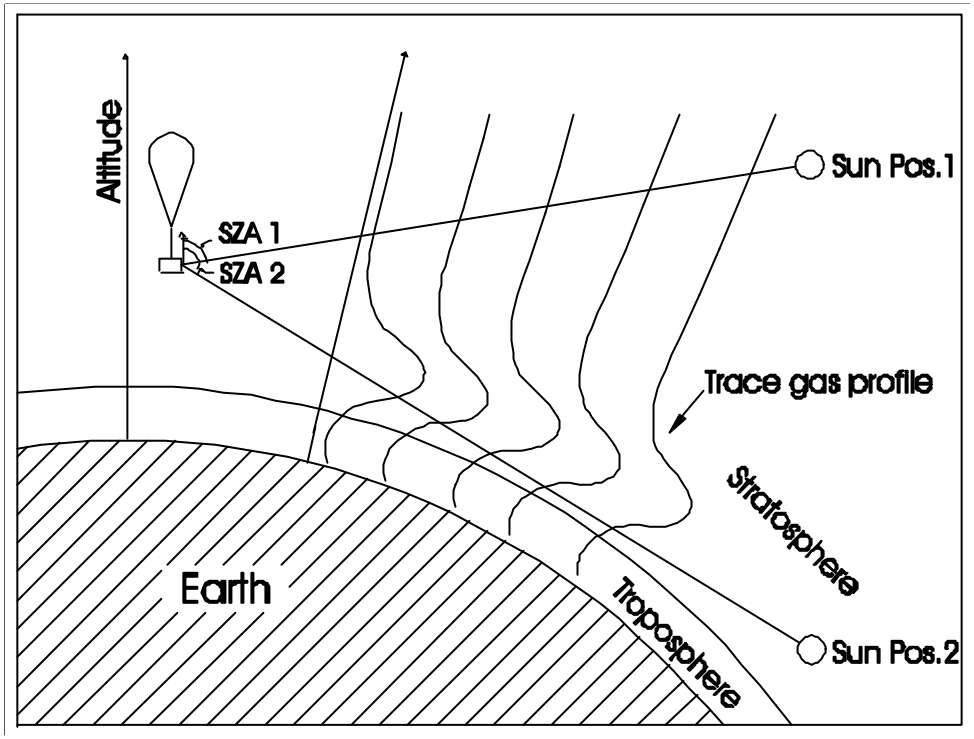
- 2 grating spectrometers in one thermostated (273 K) housing
- Cooled linear silicon CCD array
- (2048 pixels, T = 273 K)
- Wavelength range and resolution:
- UV (320 - 520 nm, ?? = 0.8 nm)
- Light intake: Glas fibre bundles
- NADIR and LIMB (+1 to -5^{o}) observations
- Total mass 5 kg
- Total power consumption ~5 W
- Target species: O3, O4, NO2, NADIR and LIMB radiance, possibly OClO, BrO

Balloon-borne solar occultation spectroscopy (UV/vis/near IR)

Balloon ascent mode at high Sun



Solar occultation at low Sun



Result 1: Meteorological forecasting by FU-Berlin

(more info is given in the talk of B. Naujokat !)

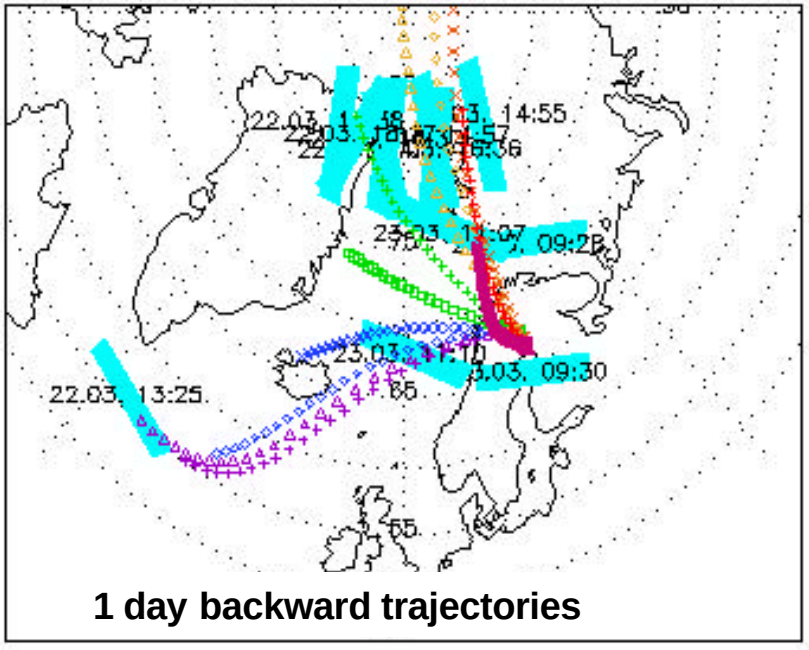
LPMA/DOAS Flight – balloon ascent in Kiruna, March 23, 03

Trajectories started at the predicted balloon measurement points and colocated LIMB scans of SCIAMACHY

start time and altitude

23.03.03 15:20 UT	25 km	23.03.03 16:30 UT	32 km
23.03.03 15:10 UT	22 km	23.03.03 16:20 UT	32 km
23.03.03 15:00 UT	19 km	23.03.03 16:10 UT	32 km
23.03.03 14:50 UT	17 km	23.03.03 16:00 UT	32 km
23.03.03 14:40 UT	14 km	23.03.03 15:50 UT	32 km
23.03.03 14:30 UT	12 km	23.03.03 15:50 UT	32 km
23.03.03 14:20 UT	10 km	23.03.03 15:40 UT	31 km
23.03.03 14:10 UT	7 km	23.03.03 15:30 UT	28 km

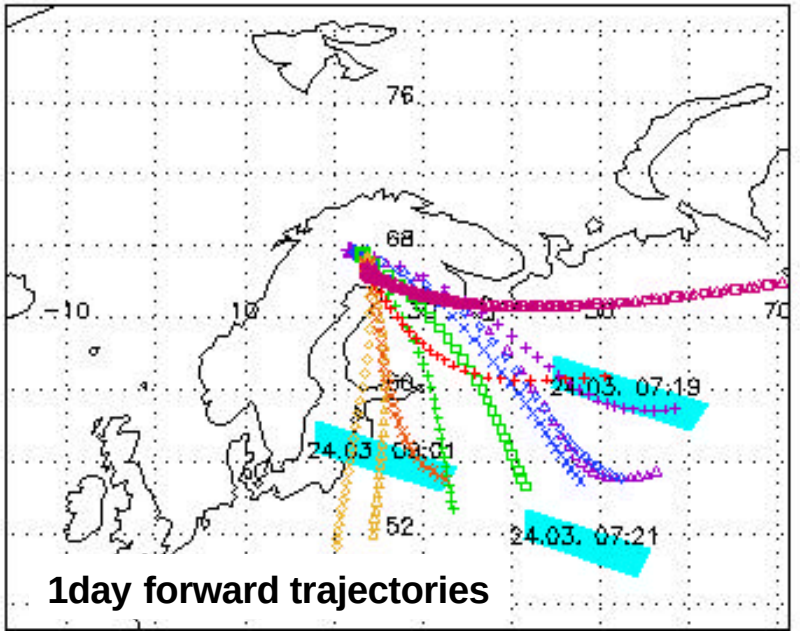
Orbit: 5532, 5533, 5534, 5535, 5544, 5545



1 day backward trajectories

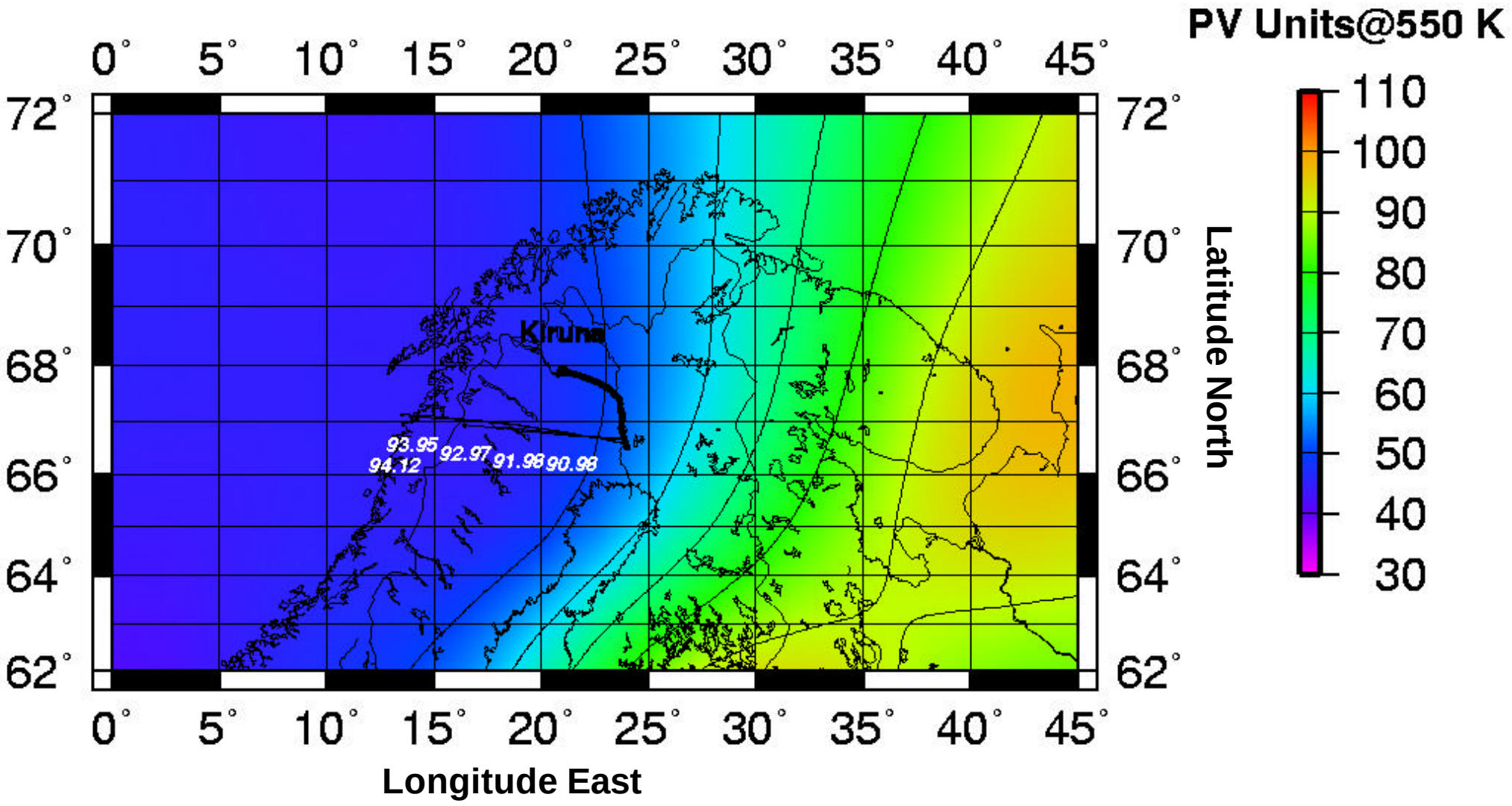
Limb scan

Orbit: 5557, 5558

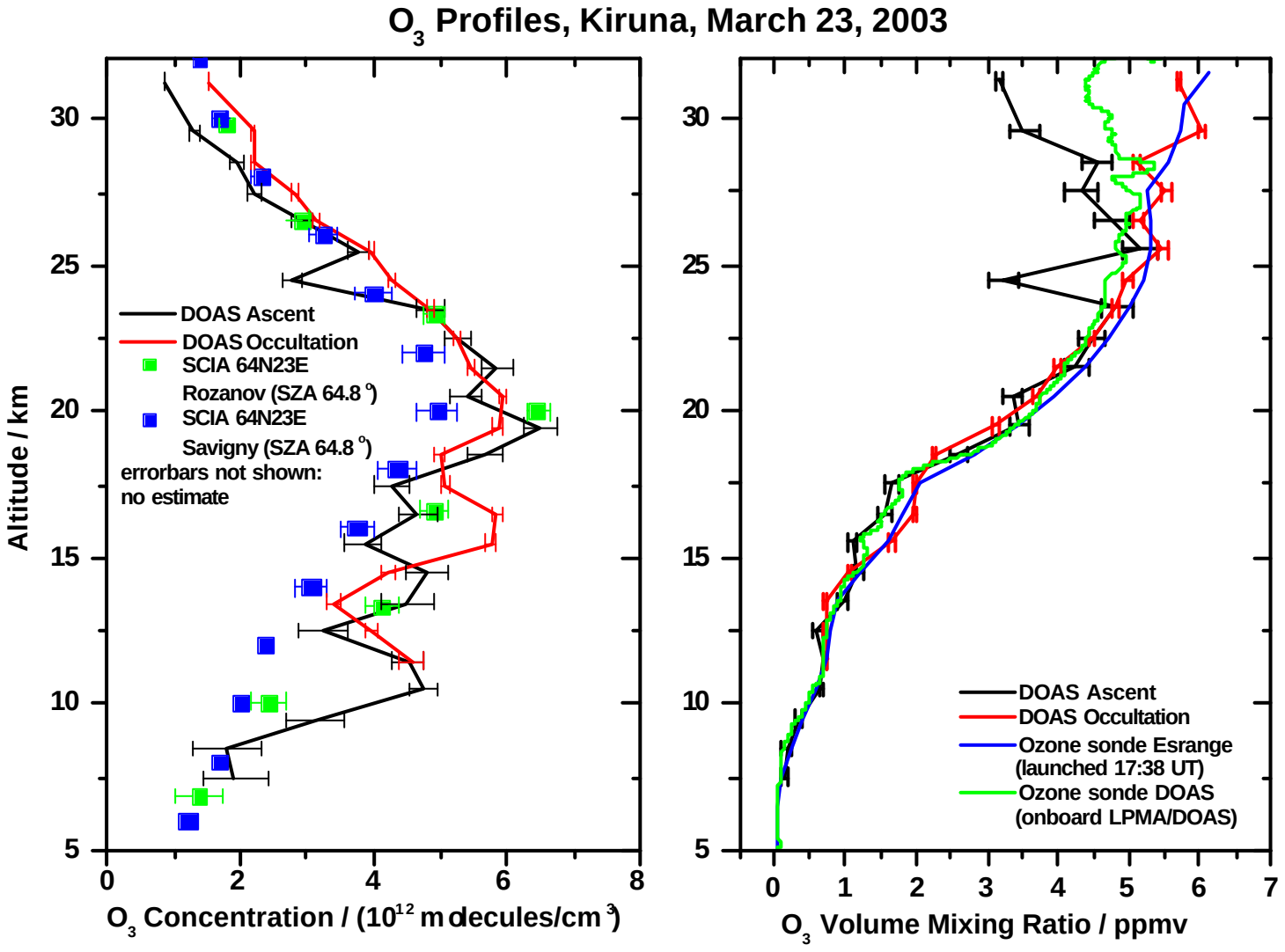


1day forward trajectories

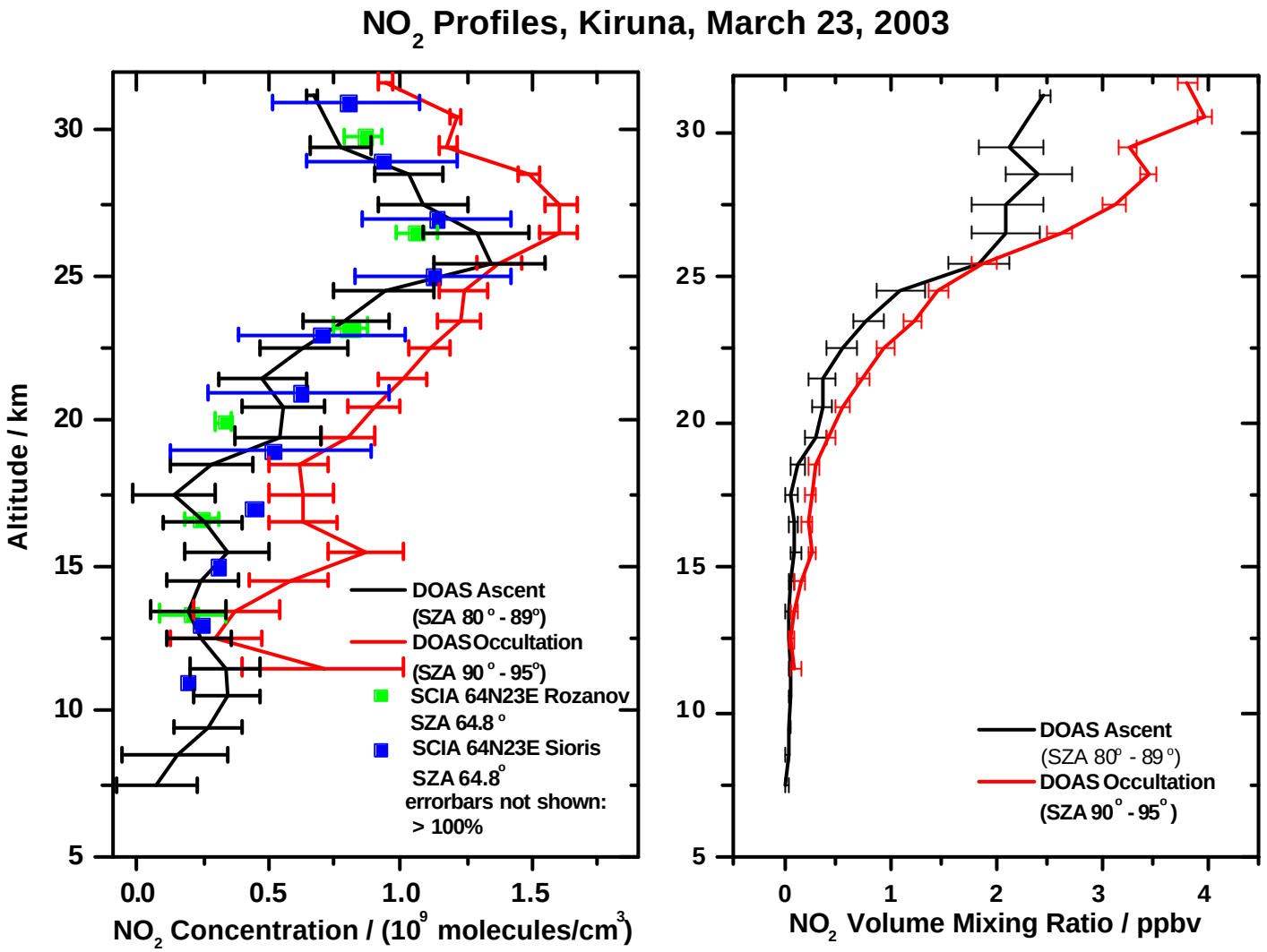
Results 2: Observation geometry PV at 550 K



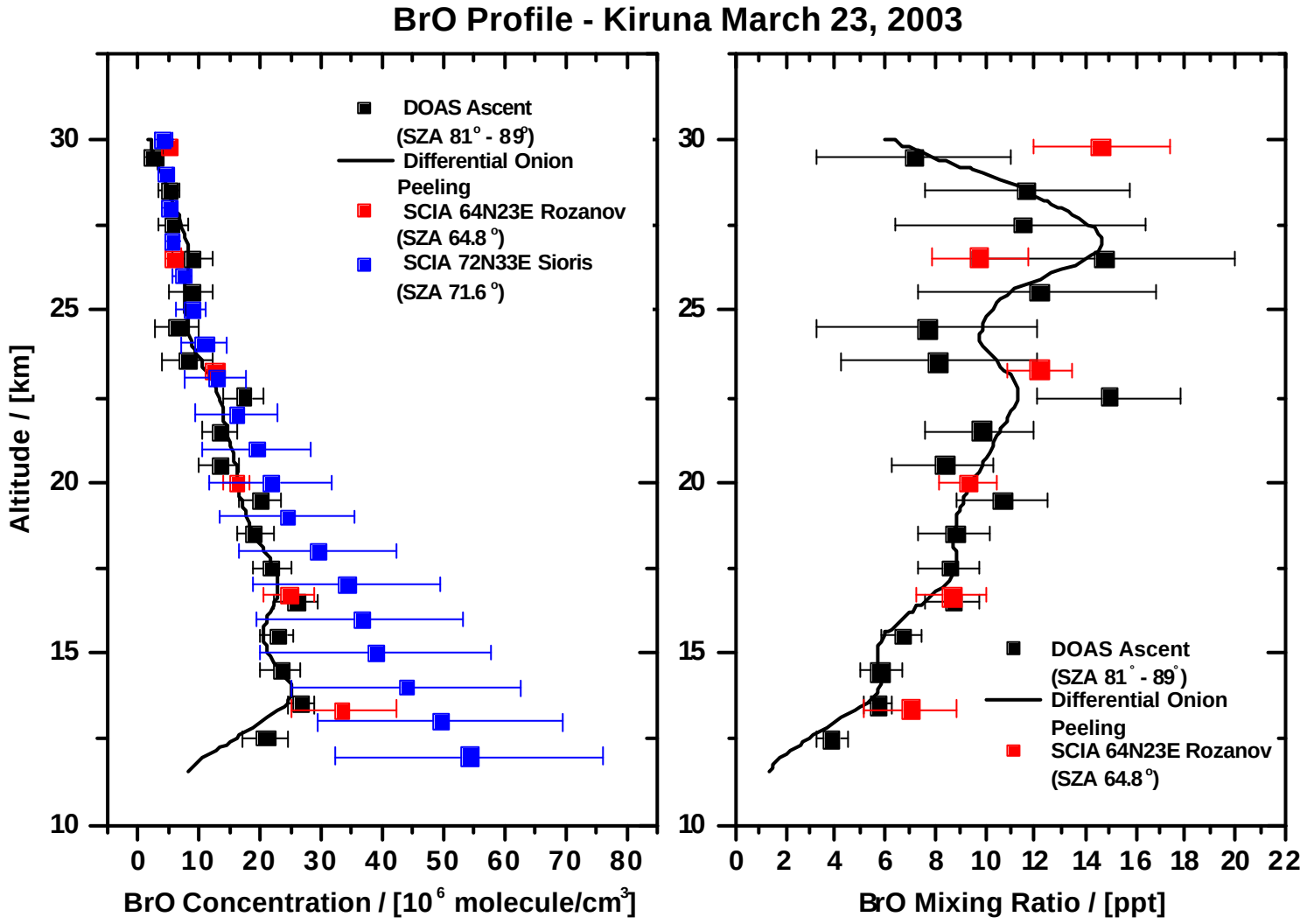
Results 3: O_3 measurements in direct Sun (DOAS), LIMB (SCIA, 64°N23°E, 9:30 UT) and ECC sondes



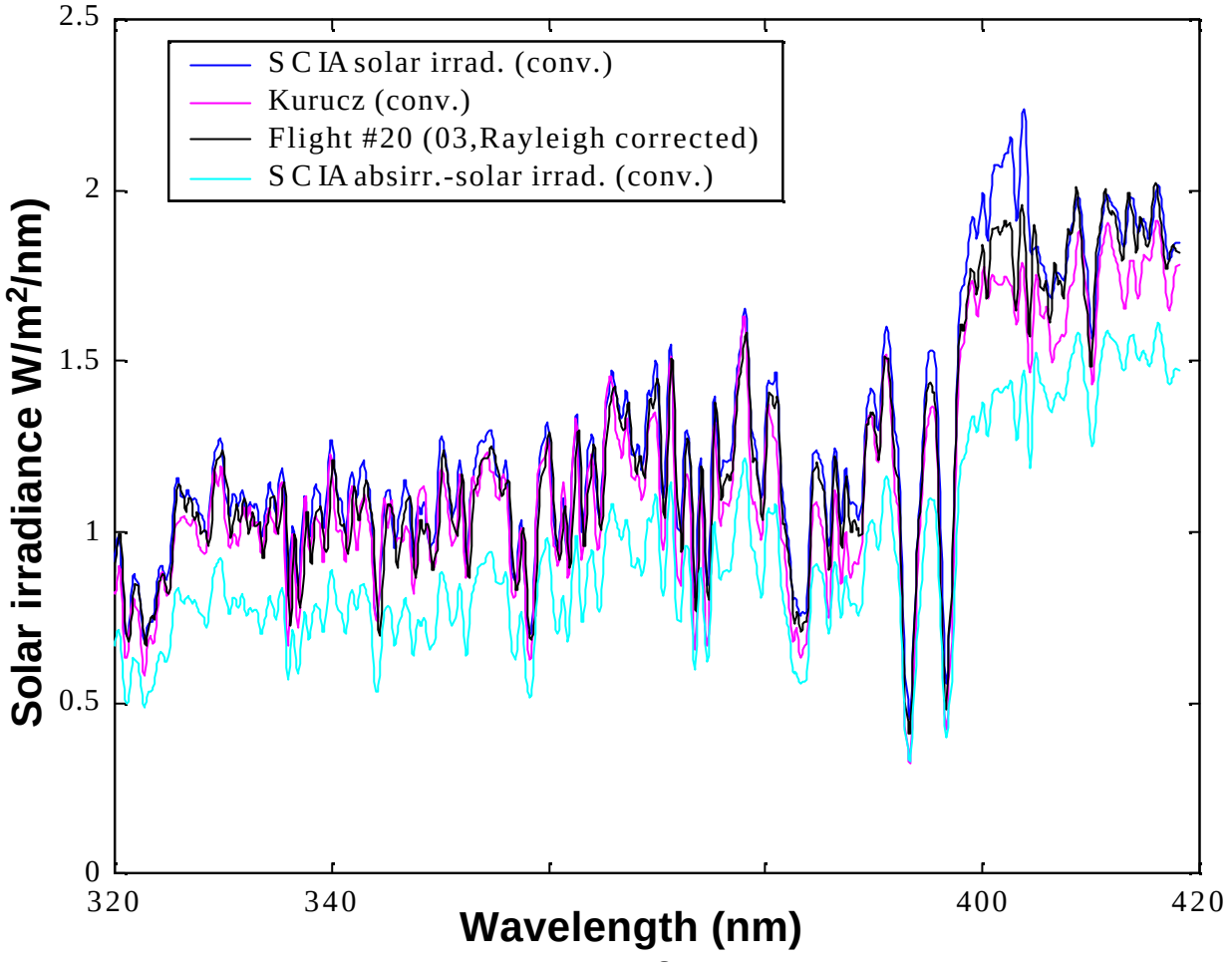
Results 4: NO_2 measurements in direct Sun (DOAS), and LIMB (SCIA, 64°N23°E, 9:30 UT)



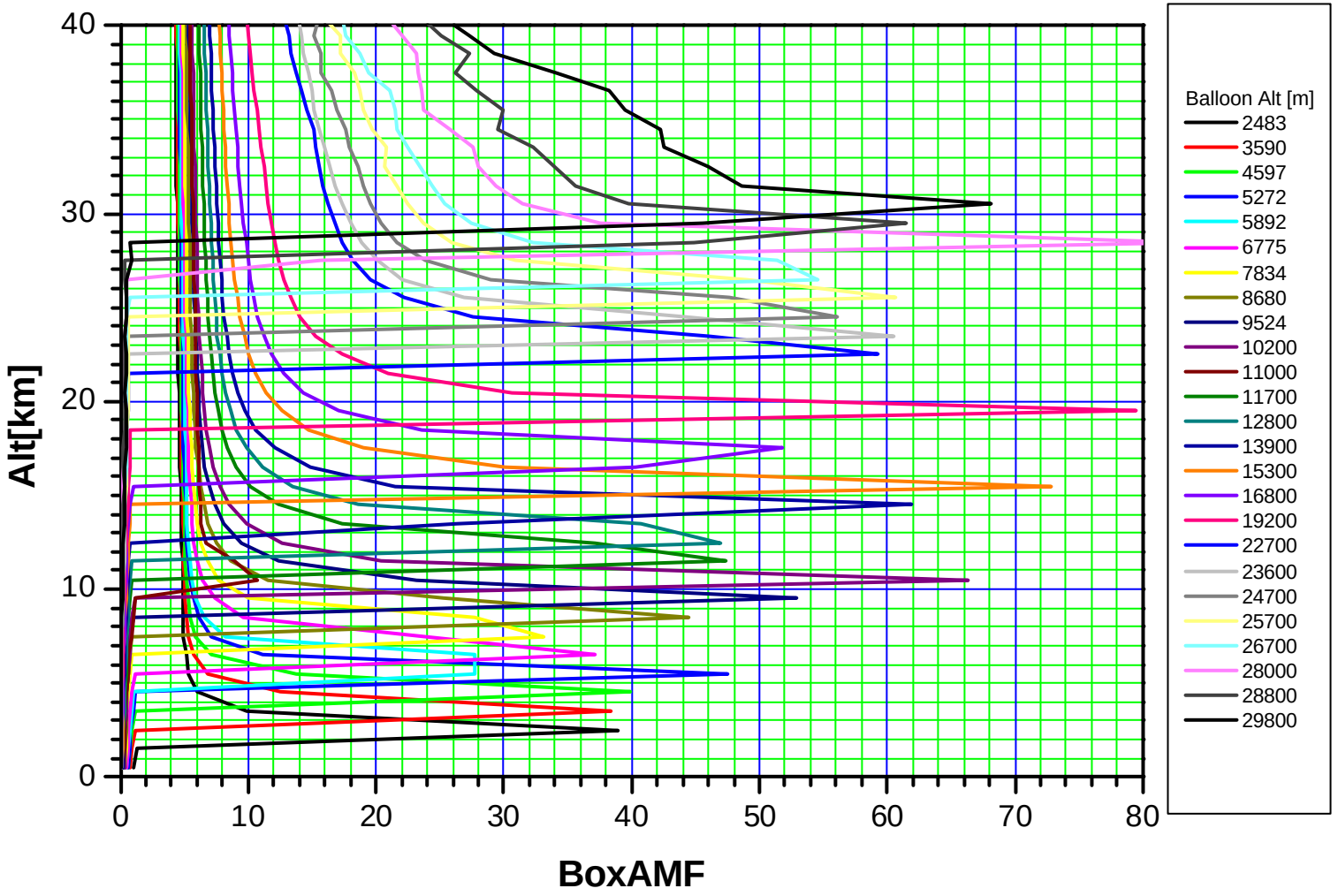
Results 5: BrO measurements in direct Sun light (DOAS) and LIMB (SCIA, 64°N23°E, 9:30 UT)



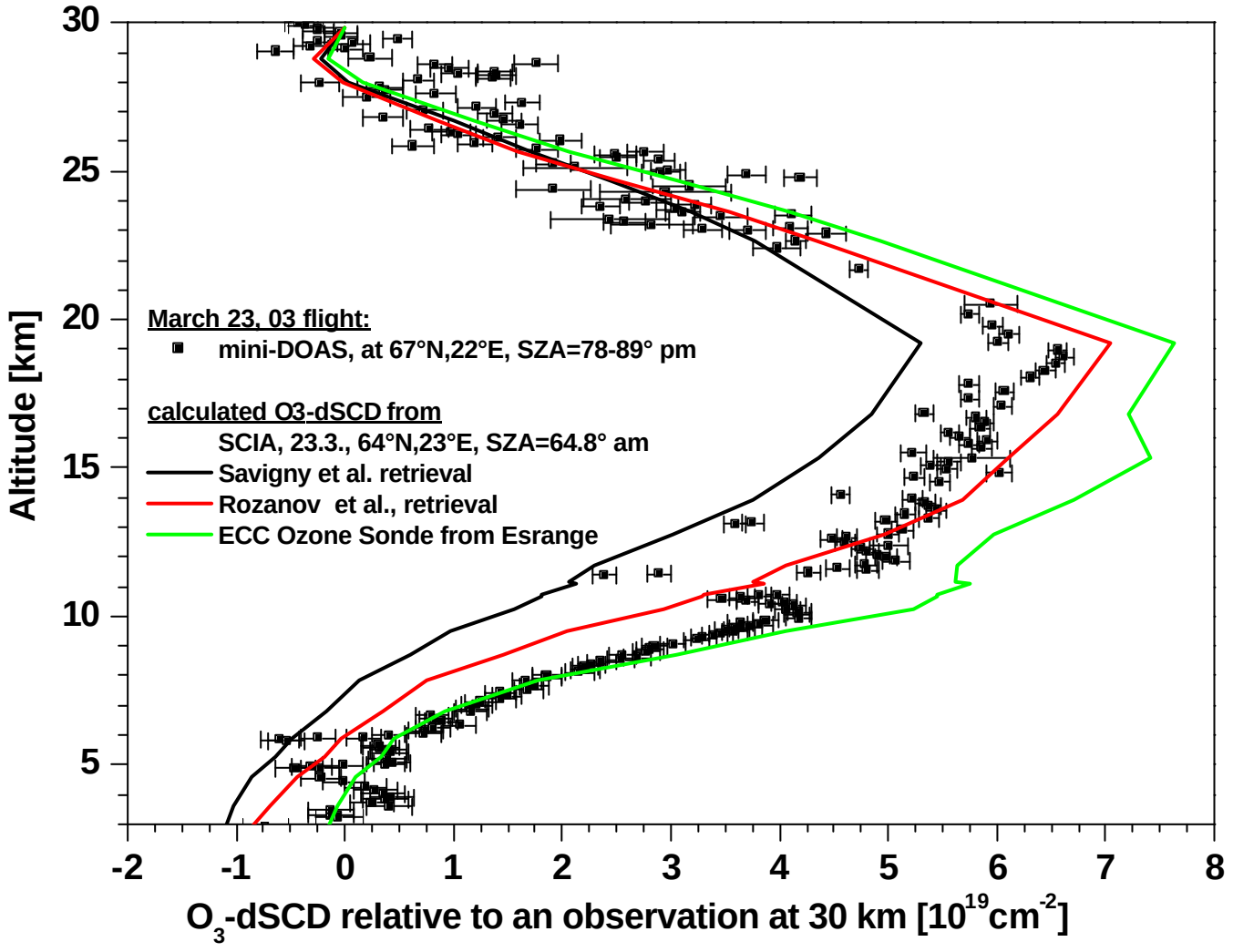
Results 6: Irradiance and radiance calibration and measurements
(more info is given in the talk of W. Gurlit)



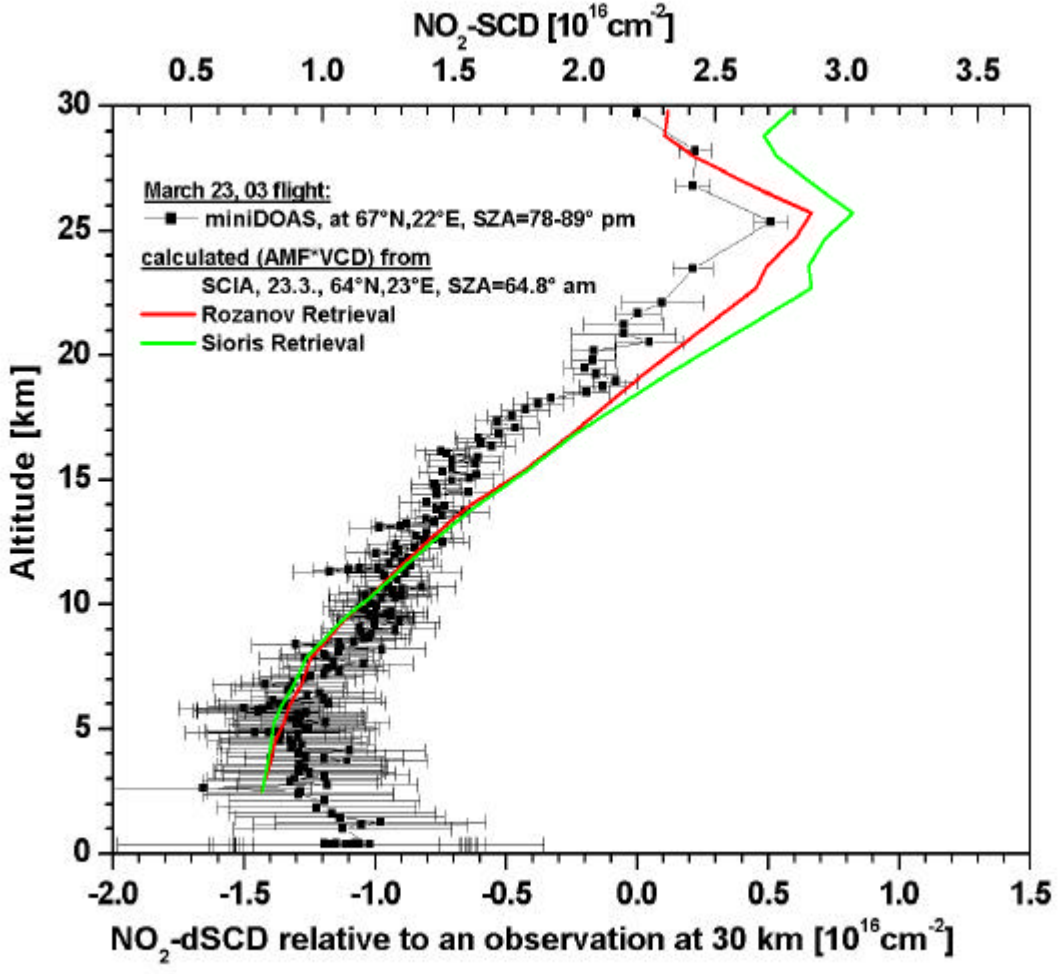
Results 7: Box Air Mass Factors for Balloon Ascent, Limb Geometry calculated by Monte Carlo Radiative Transfer Model „TRACY“



Results 8: Ozone measurements LIMB (miniDOAS) and LIMB (SCIA, 64°N23°E, 9:30 UT) on March 23, 03



Results 9: NO_2 measurements LIMB (miniDOAS) and LIMB (SCIA, 64°N23°E, 9:30 UT) on March 23, 03



Summary & Conclusions

1.) **Results:** Comparison of our balloon-borne DOAS measurements (March 23, 03) with SCIAMACHY-LIMB retrievals indicate, even though somewhat different air masses (around the vortex edge) were probed,

- O_3 an agreement of typically ± 10 %, mostly coming from uncertainties in the radiative transfer and the vortex edge situation probed
- NO_2 of typically ± 25 % owing to missing photochemical corrections, T-dependence of the NO_2 cross section, uncertainties in the Fraunhofer NO_2 amount, radiative transfer,
- LIMB RT code is validated by mini-DOAS observations of O_3, and NO_2
- BrO of typically < ± 25 % above 20 km and ± 50 % below 20 km mostly coming from uncertainties in the spectral retrieval and RT modeling
- the solar irradiance in the UV < ± 5 %

2.) **Upcoming activities** will include

- improvements of the balloon and SCIA-LIMB retrievals (see above)
- more validation flights (3 ?) at high, mid- and low latitudes
- air mass match calculations necessary due to the mismatch of probed vortex edge air masses for the March 23, 03 flight