

## 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 to 50 km	n/s	n/s
O <sub>3</sub>	DOAS	? 0.3 %	? 0.5 % 10 <sup>10</sup> molecule/cm <sup>3</sup>	5 to 30/40 km	0 to 60 km	? 3 %	? 5 %
O <sub>3</sub>	LPMA	? 4%	(? 4%,iv), ? 6%	5 to 30/40 km	0 to 60 km	? 3 %	? 5 %
O <sub>4</sub>	DOAS	? 4 %	? 4 %	5 to 30 km	0 to 25 km	n/s	n/s
NO <sub>2</sub> (i)	DOAS	? 2.0 %	<? 4.0 % ? 10 <sup>9</sup> mole/cm <sup>3</sup>	5 to 30/40 km	0 to 40 km	? 10 %	? 15 %
NO <sub>2</sub> (i)	LPMA	? 11.0 %	(? 6.0 %,iv), ? 12.5%	15 to 30/40 km	0 to 40 km	? 10 %	? 15 %
NO <sub>3</sub> (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 <sup>12</sup> mole/cm <sup>3</sup>	5 to 30/40 km	15 to 35 km	? 80 % UT ? 40 % LT	? 15 %
OCIO (i)	DOAS	? 3.0 %	? 8.0 %	5 to 30/40 km	15 to 35 km	n/s	n/s
CH <sub>4</sub>	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 <sub>2</sub> O	LPMA	? 10	(? 3 %,iv), ? 11 %	5 to 30/40 km	0 to 40 km	? 1% UT/ ? 2% LS	? 2% UT/ ? 4% LS
CO <sub>2</sub>	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, OCIO, BrO, IO, OIO, and Mie extinction, solar irradiance

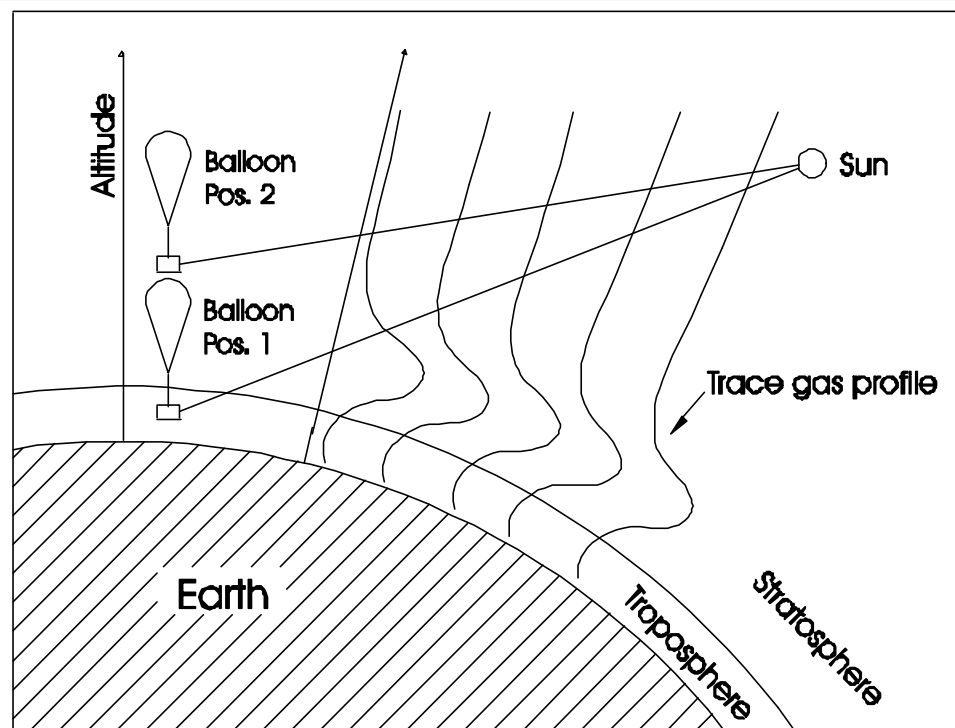
### Mini-DOAS instruments (NADIR&LIMB):

- 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°) observations
- Total mass 5 kg
- Total power consumption ~5 W
- Target species: O3, O4, NO2, NADIR and LIMB radiance, possibly OCIO, BrO

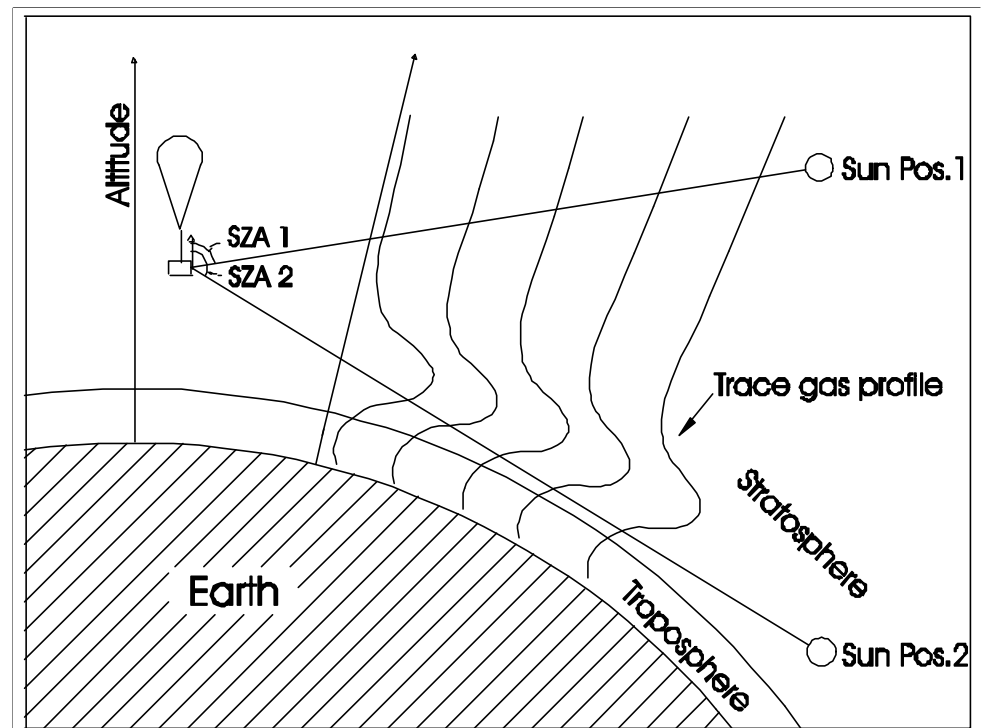


## Balloon-borne solar occultation spectroscopy (UV/vis/near IR)

**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 !)

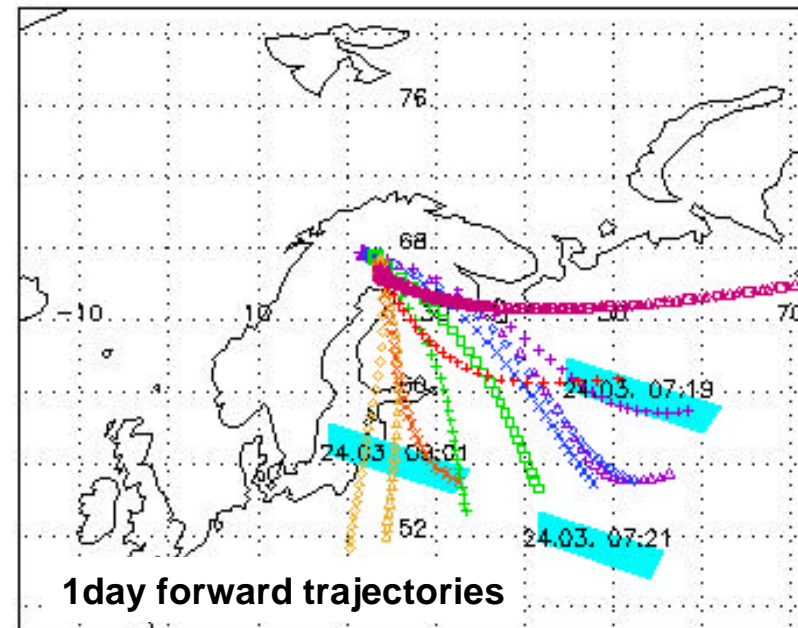
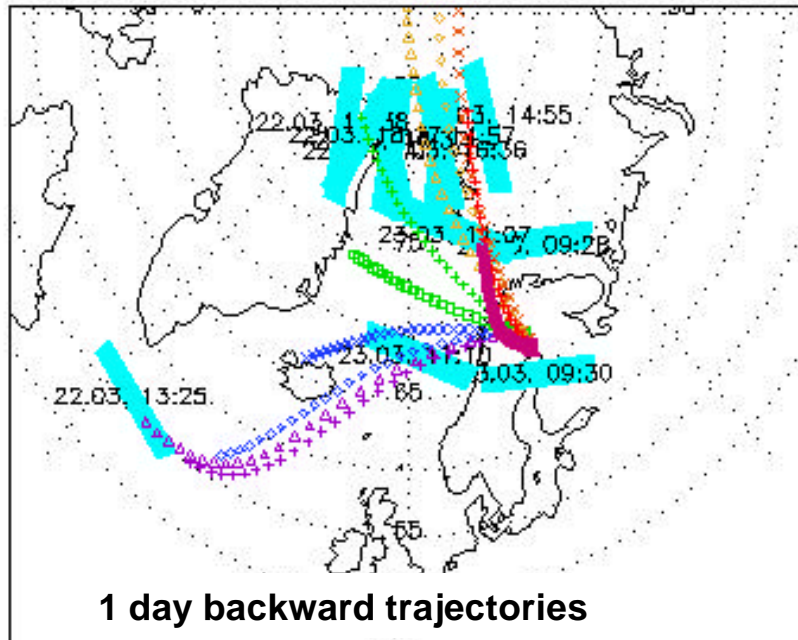
## LPMA/DOAS Flight – balloon ascent in Kiruna, March 23, 03

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 18:30 UT	32 km
△	23.03.03 15:10 UT	22 km	+	23.03.03 18:20 UT	32 km
+	23.03.03 15:00 UT	19 km	□	23.03.03 18:10 UT	32 km
□	23.03.03 14:50 UT	17 km	×	23.03.03 18:00 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

Orbit: 5557, 5558

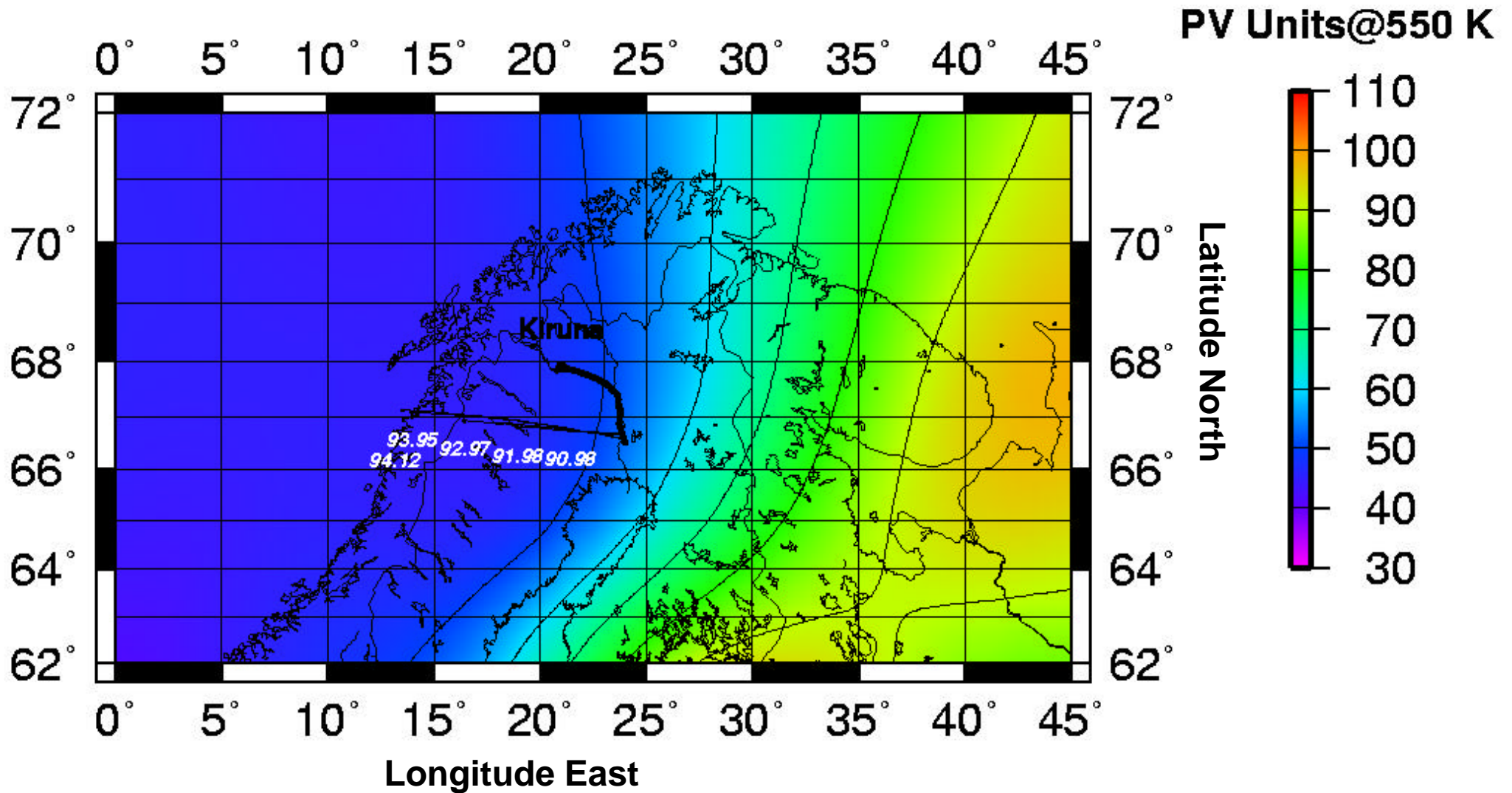


Limb scan





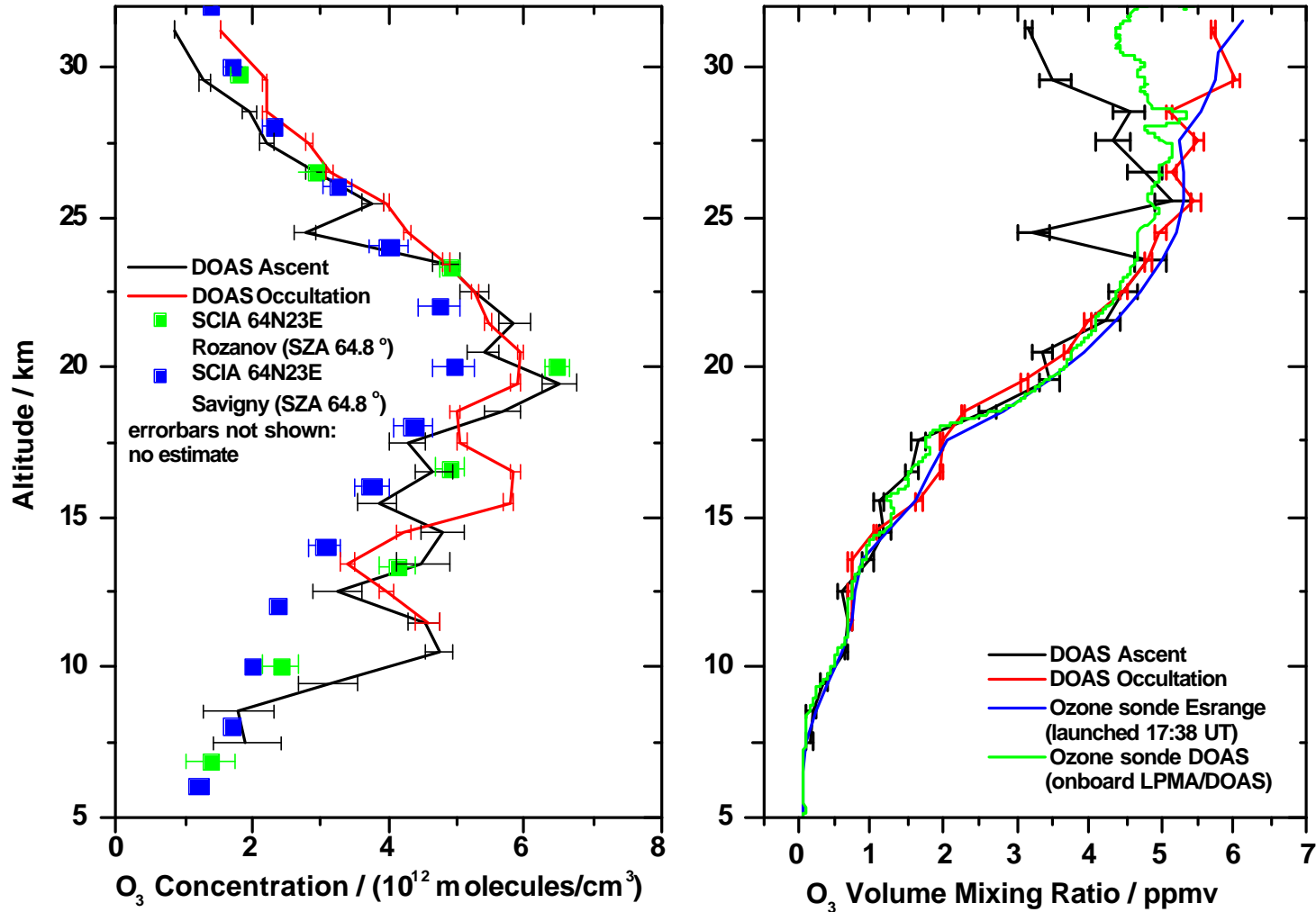
## Results 2: Observation geometry PV at 550 K



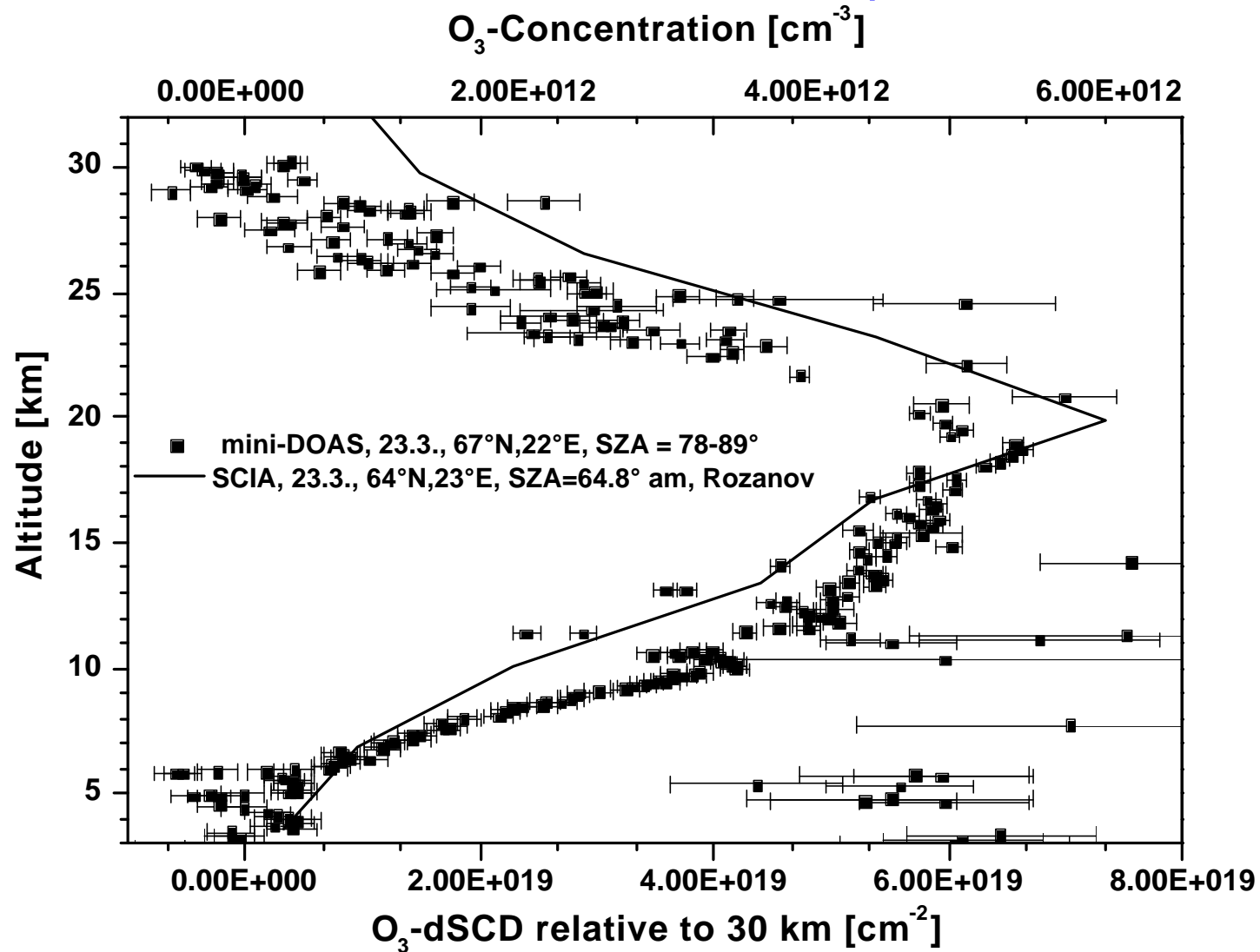


# Results 3: O<sub>3</sub> measurements in direct Sun (DOAS), LIMB (SCIA, 64°N23°E, 9:30 UT) and ECC sondes

## O<sub>3</sub> Profiles, Kiruna, March 23, 2003

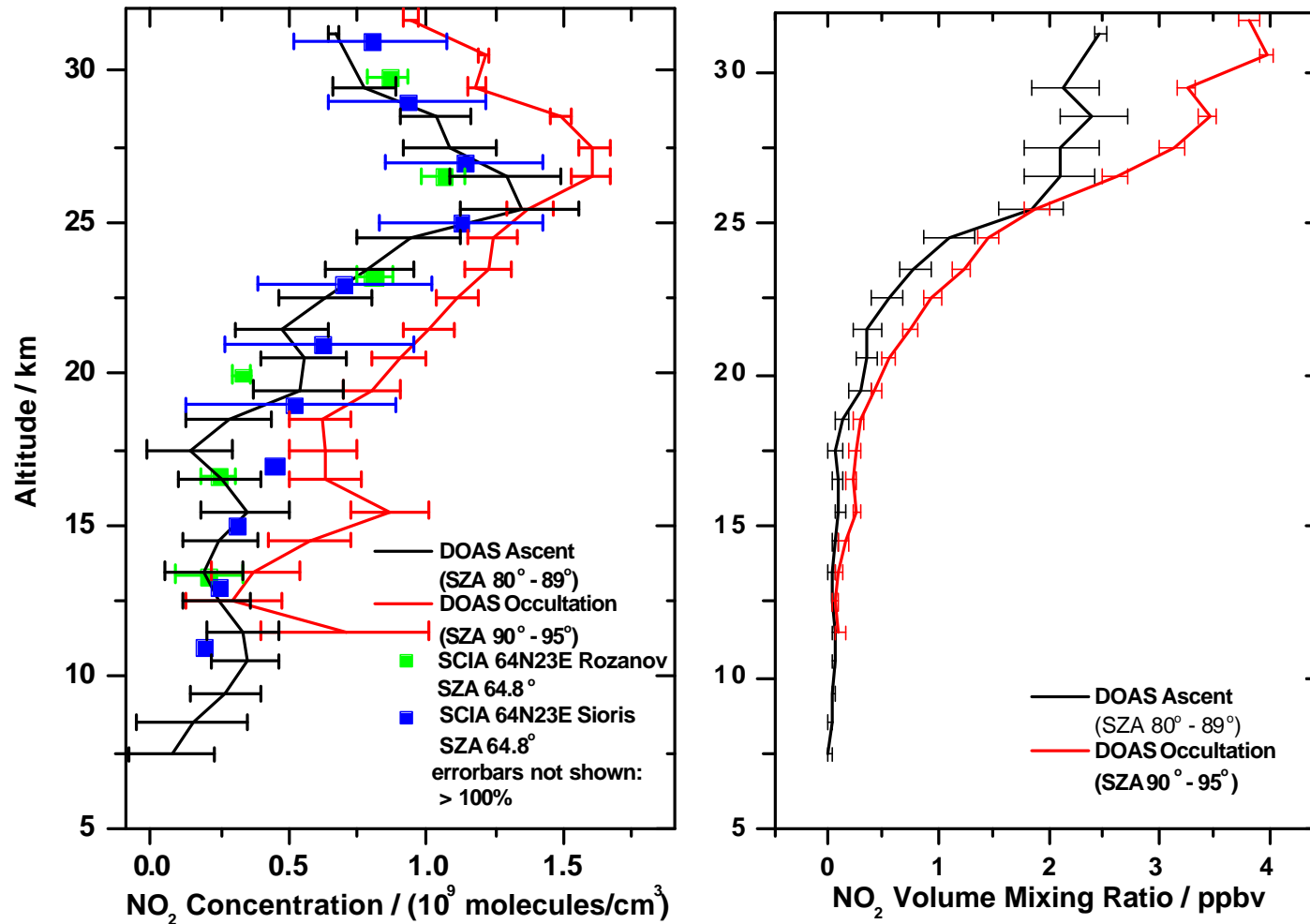


## Results 4: Ozone measurements LIMB (DOAS) and LIMB (SCIA, 64°N23°E, 9:30 UT)



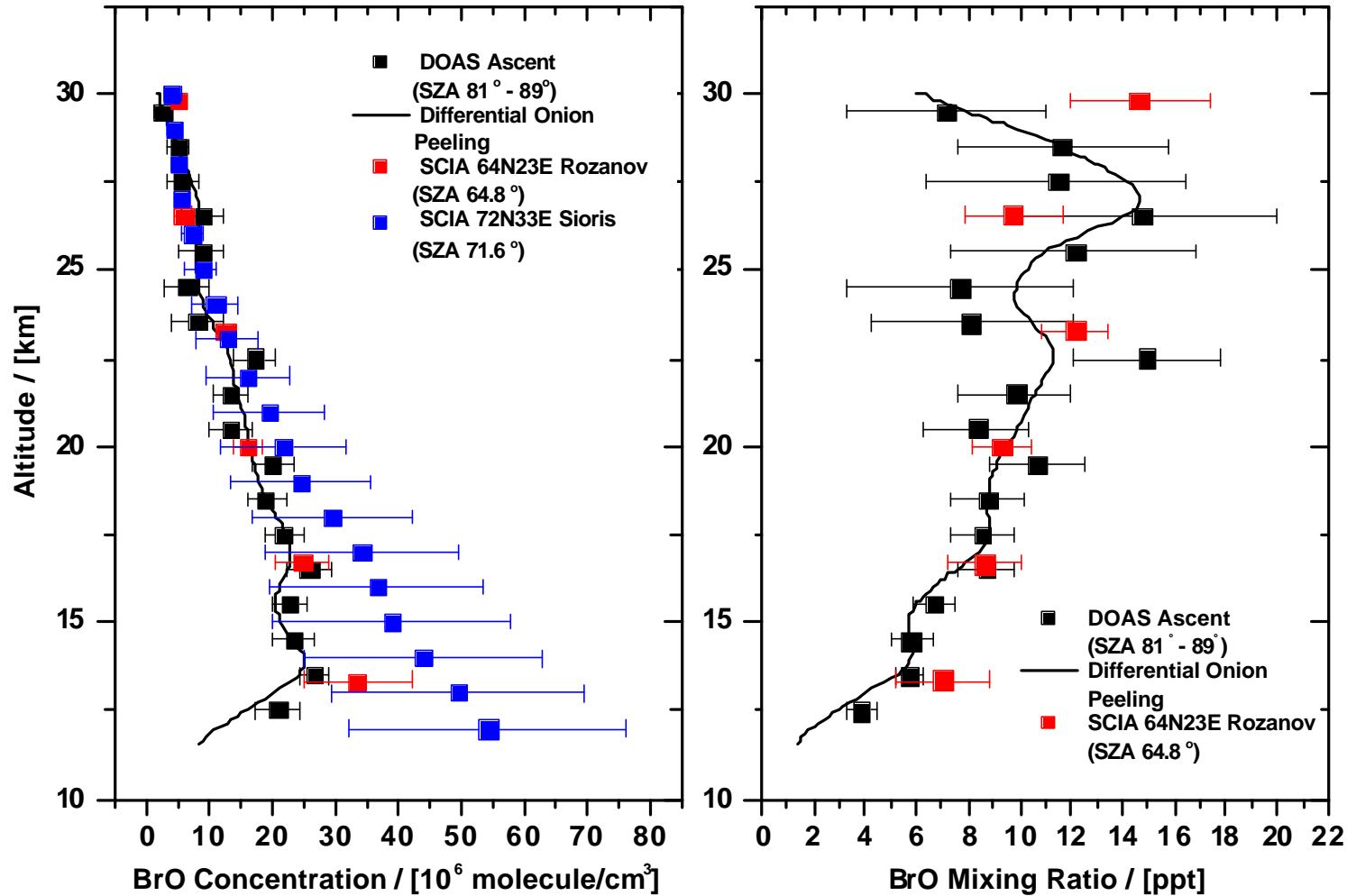
# Results 5: NO<sub>2</sub> measurements in direct Sun (DOAS), and LIMB (SCIA, 64°N23°E, 9:30 UT)

## NO<sub>2</sub> Profiles, Kiruna, March 23, 2003



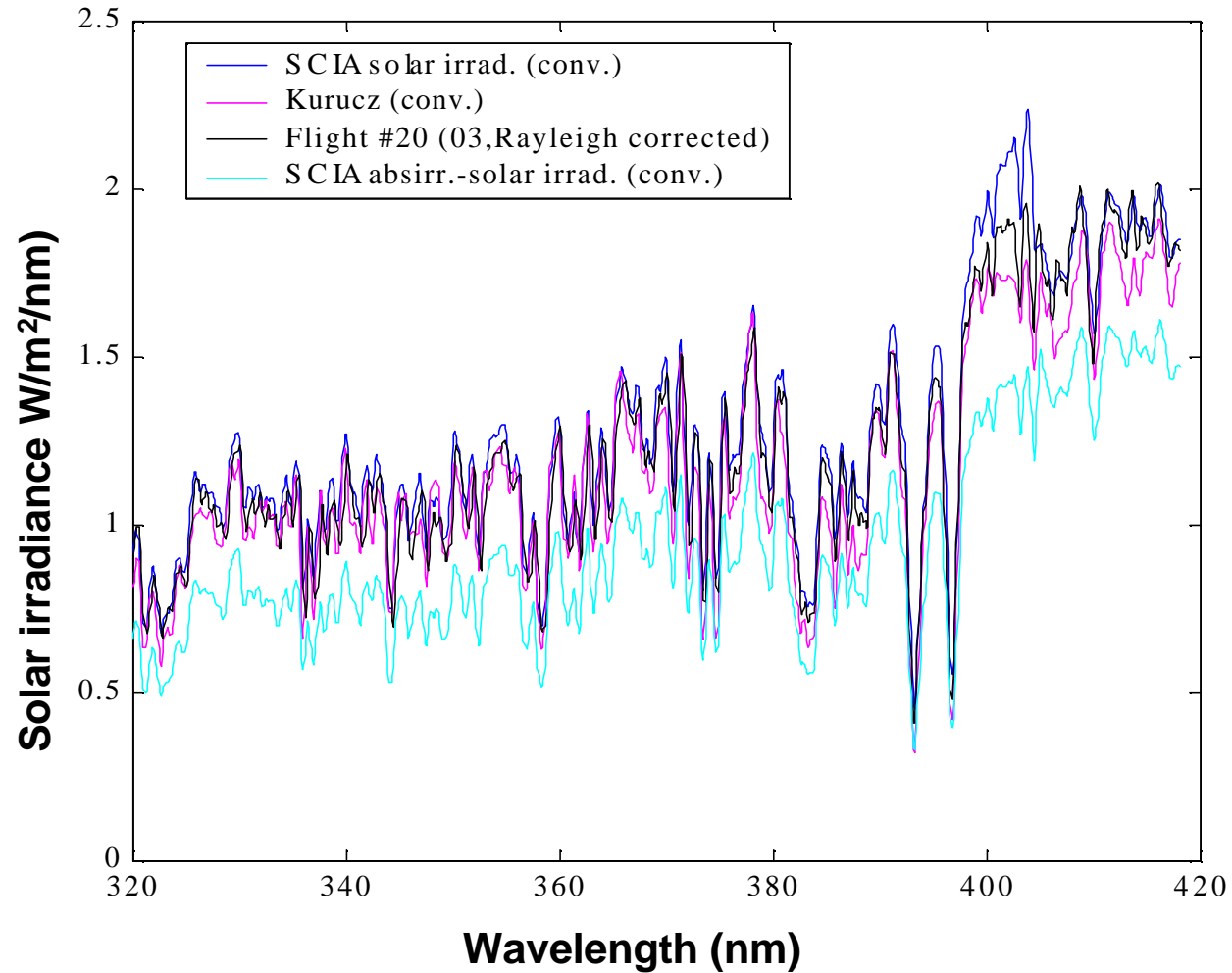
# Results 6: BrO measurements in direct Sun light (DOAS) and LIMB (SCIA, 64°N23°E, 9:30 UT)

## BrO Profile - Kiruna March 23, 2003



## Results 7: Irradiance and radiance calibration and measurements (more info is given in the talk of W. Gurlit)

3, 03



## 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<sub>3</sub> an agreement of typically  $\pm 10\%$ , mostly coming from uncertainties in the radiative transfer and the vortex edge situation probed
  - NO<sub>2</sub> of typically  $\pm 25\%$  owing to missing photochemical corrections, T-dependence of the NO<sub>2</sub> cross section, uncertainties in the Fraunhofer NO<sub>2</sub> amount, radiative transfer, .....
  - BrO of typically  $< \pm 25\%$  above 20 km and  $\pm 50\%$  below 20 km mostly coming from uncertainties in the spectral retrieval radiative transfer
  - the solar irradiance in the UV  $< \pm 5\%$
  
- 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

