

**MIPAS NO<sub>2</sub>**  
**ACVT subgroup: All**  
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**A. Martinez, I. Kostadinov**

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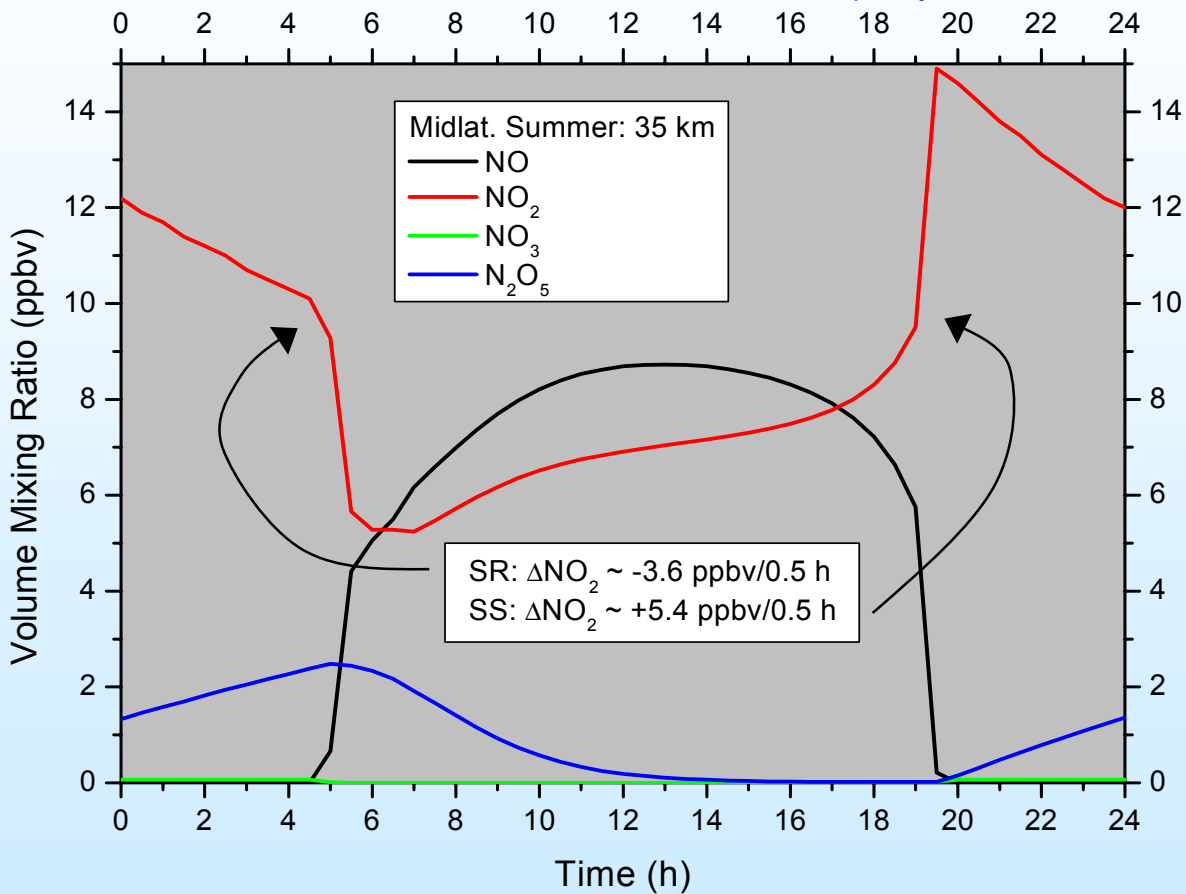
**T. Blumenstock**

IMK-ASF, Forschungszentrum Karlsruhe, Germany

**F. Hendrick, M. Van Roozendaal, M. De Mazière**

Belgian Institute for Space Aeronomy, Brussels, Belgium

## Diurnal variation of NO<sub>x</sub> species



→ Temporal variation of NO<sub>2</sub> has to be taken into account during validation process, especially during SR and SS.

## SPIRALE (in-situ) - Balloon (courtesy: M. Pirre)

(LPCE/CNRS, Orléans, France)

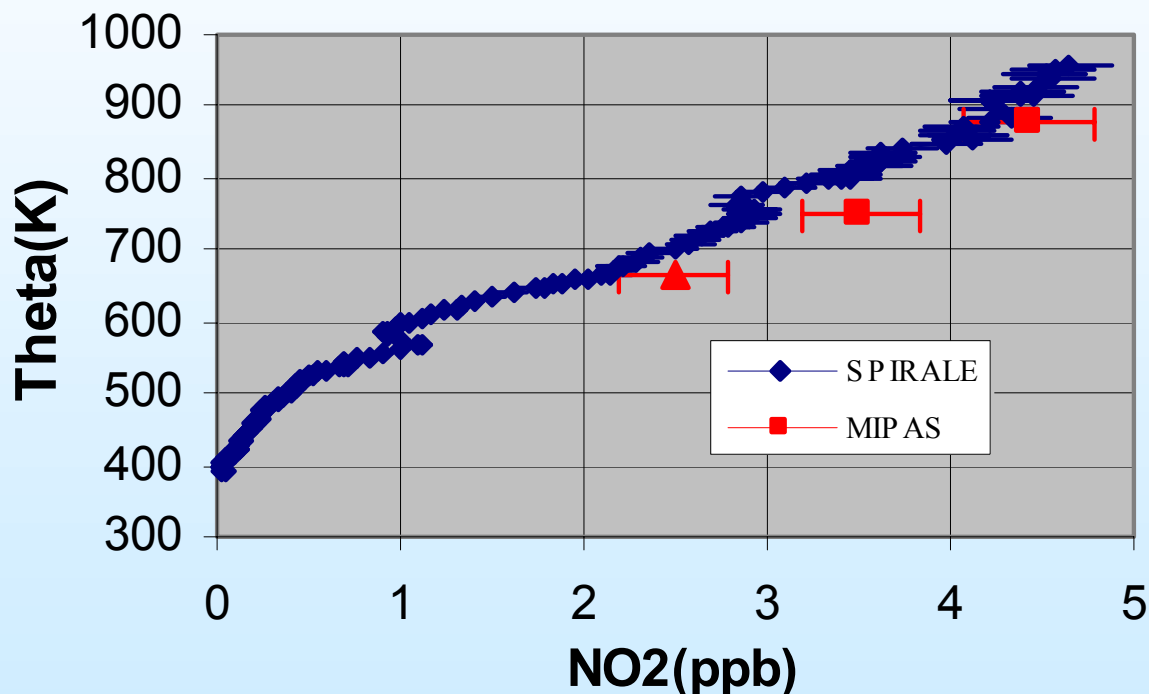
Midlatitudes (late morning),  
Aire-sur-l'Adour, 43°N,  
(Sep./Oct. 2002):

SPIRALE: 2 October 2002,  
9.30 - 10.00 LT  
(no MIPAS data available on 2-10-2002)

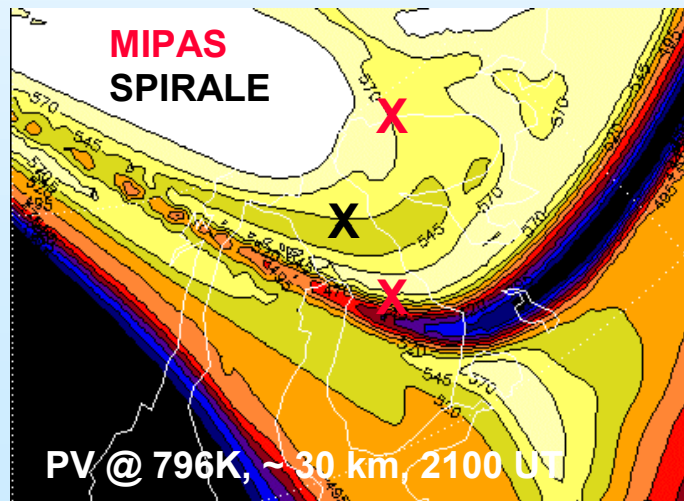
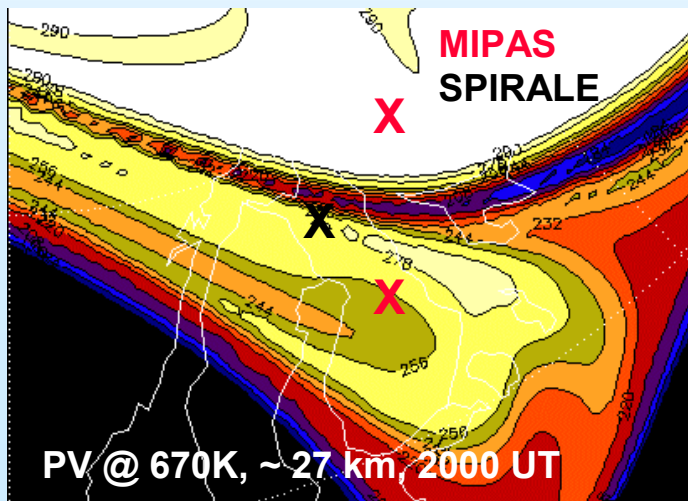
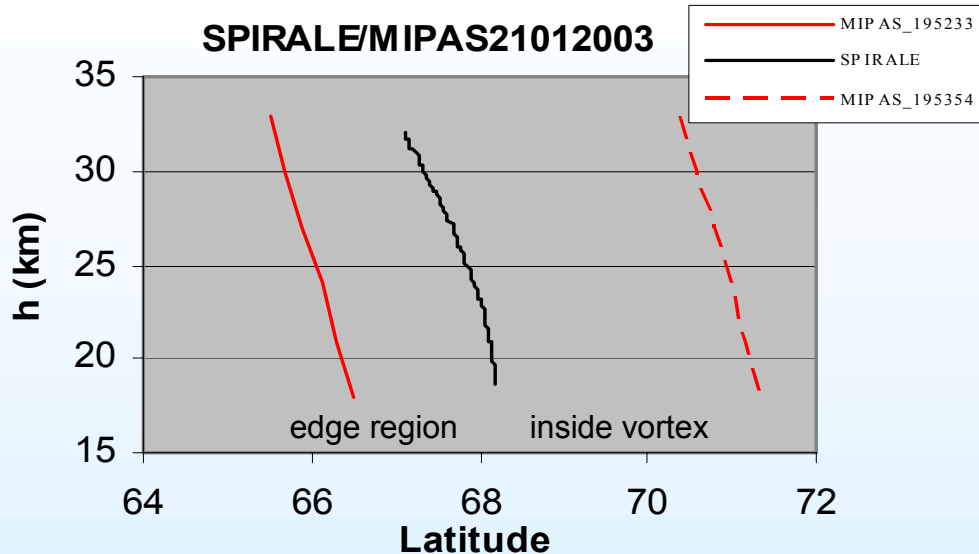
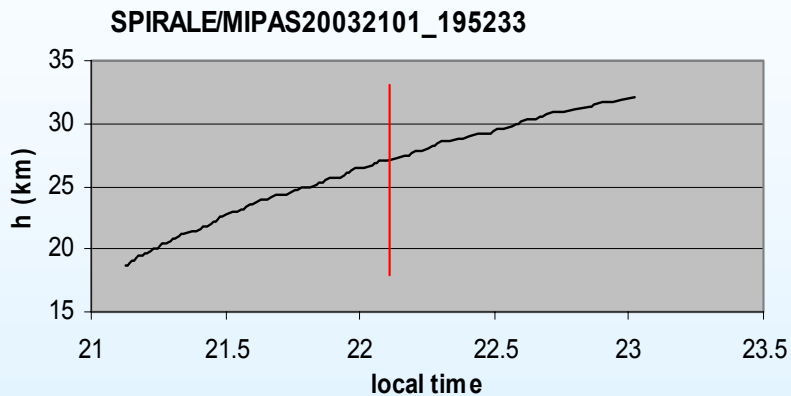
→ Backward trajectory  
calculations to match MIPAS  
(v4.61) on 25 Sep. (triangle)  
and 27 Sep. (squares) at 10:10  
LT)

→ Photochemical difference  
MIPAS - SPIRALE  $\leq 0.3$  ppbv

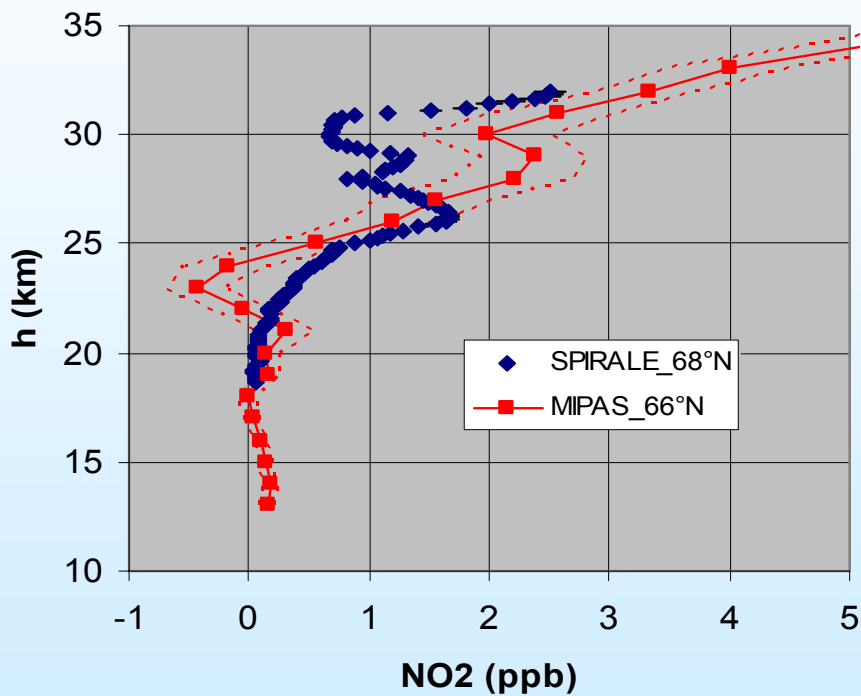
SPIRALE/MIPAS\_200209\_v4.61



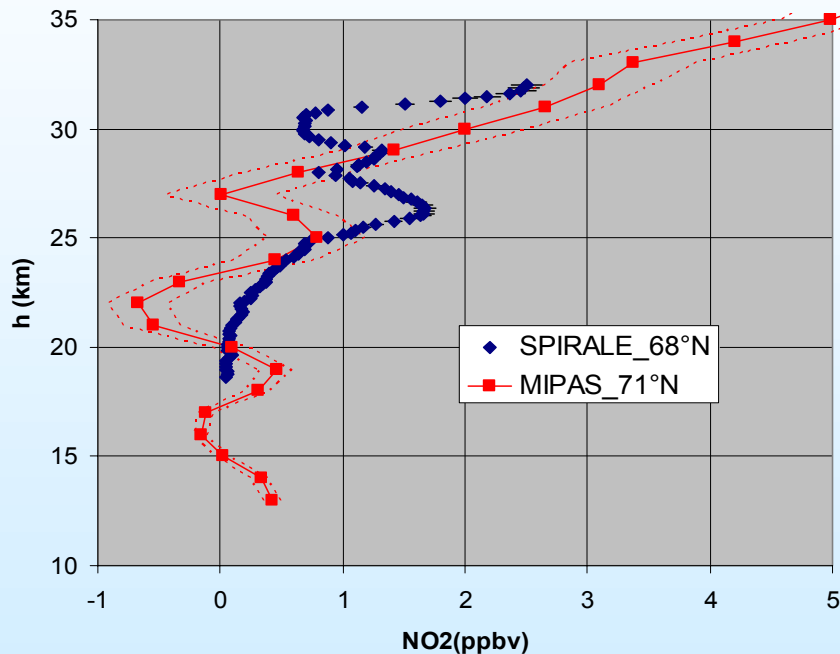
## Arctic winter (night), Kiruna (Jan. 2003):



**SPIRALE/MIPAS 20032101\_195233**



**SPIRALE/MIPAS20032101\_195354**



MIPAS-IMK (preliminary) offline V1/4.55 data, courtesy: B. Funke (IAA/IMK)

## MIPAS-B (FTIR) - Balloon (Sep. 2002)

(IMK-ASF, Karlsruhe, Germany)

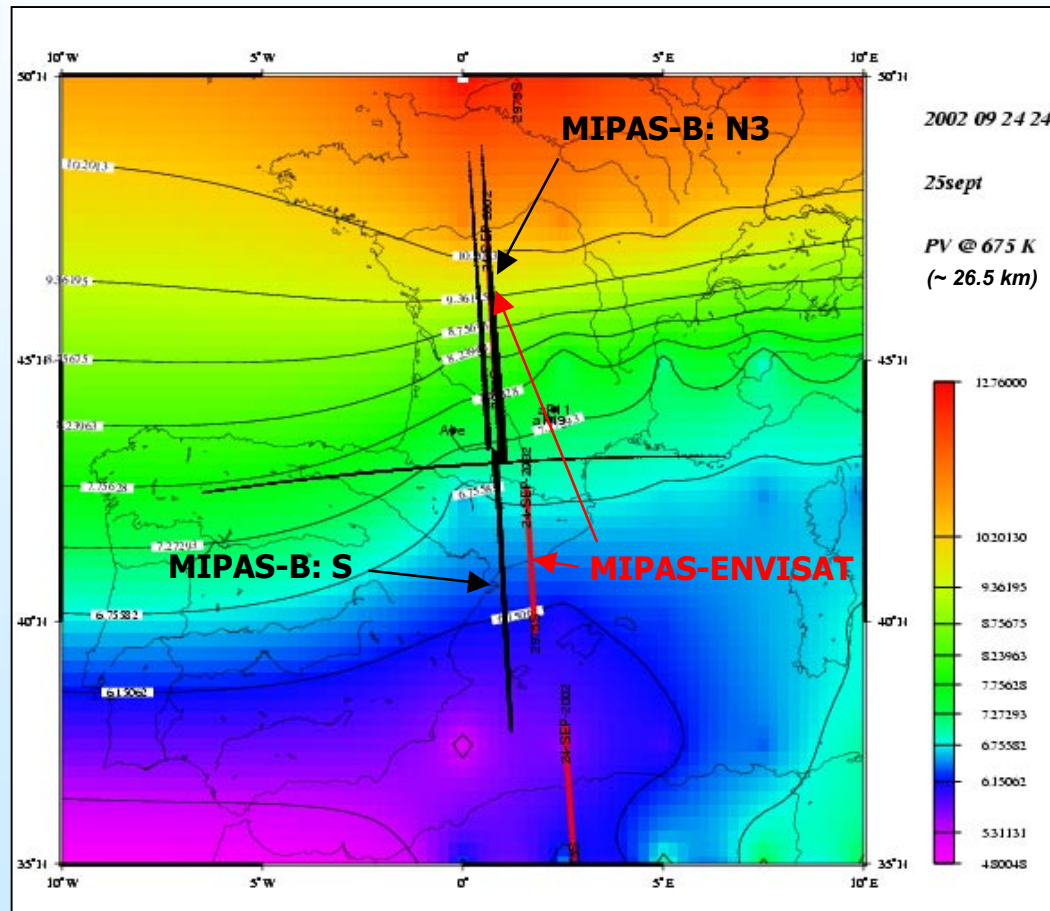
Midlatitudes (night),  
Aire-sur-l'Adour, 43°N,  
24 Sep. 2002:

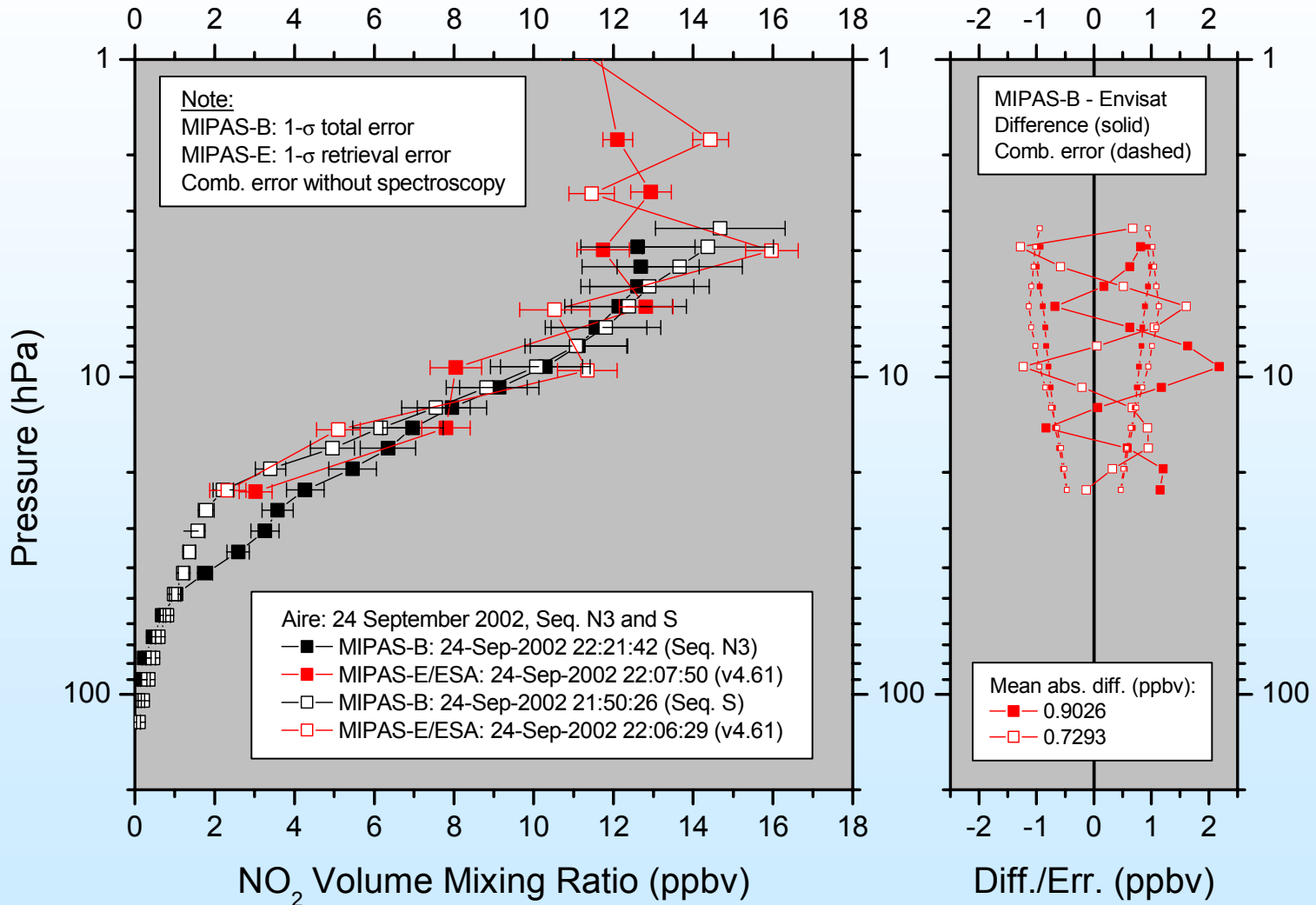
Match of ENVISAT evening overpass  
(orbit 2975).

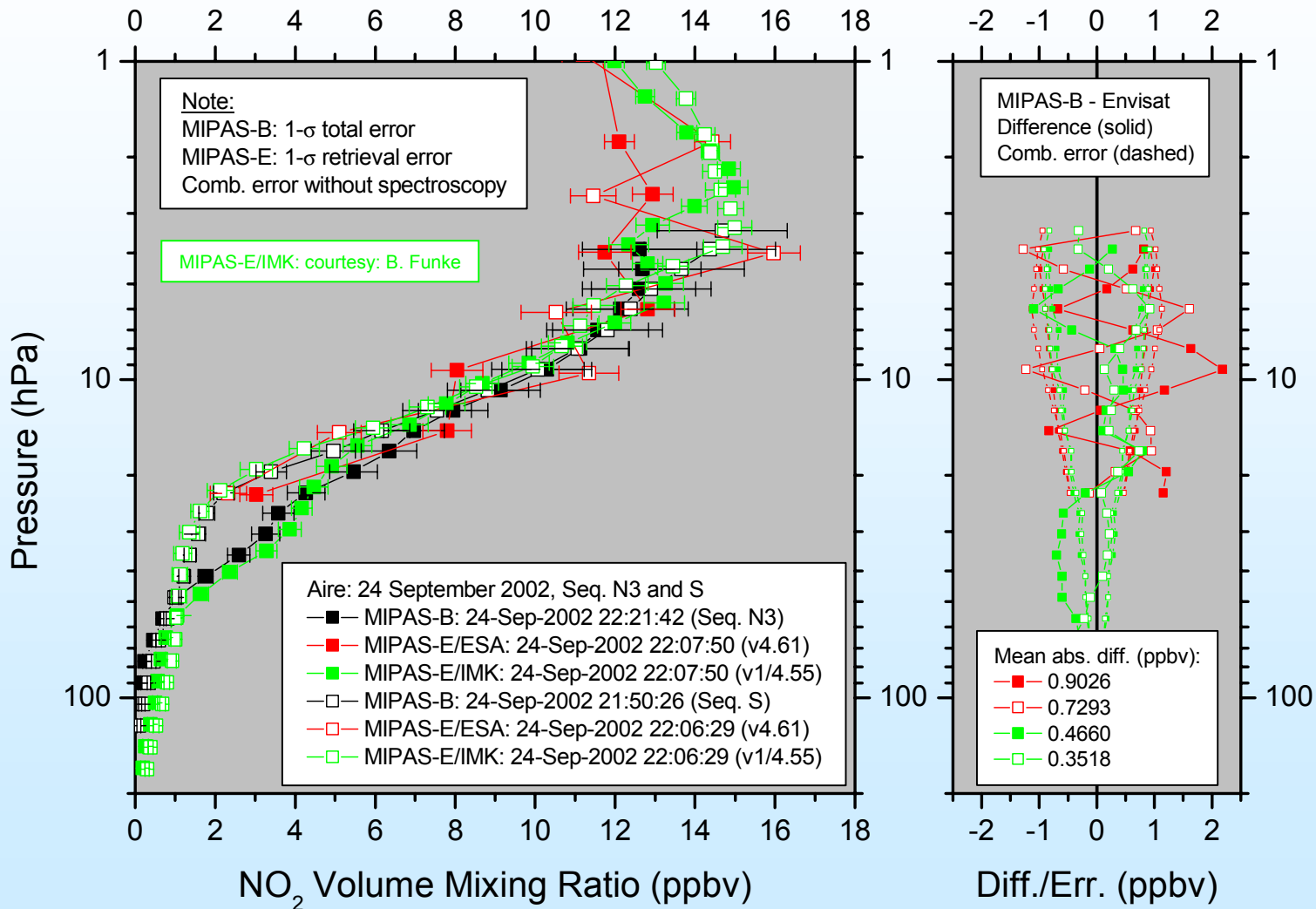
	Seq. S	Seq. N3
mean observation time:		
MIPAS-B:	21:50 UT	22:21 UT
MIPAS-E:	22:06 UT	22:07 UT

	Seq. S	Seq. N3
mean meas. coordinates:		
MIPAS-B:	39.9°N, 1.1°E	47.0°N, 0.7°E
MIPAS-E:	41.7°N, 1.6°E	46.4°N, 0.6°E

→ Perfect coincidence in terms of  
time and location







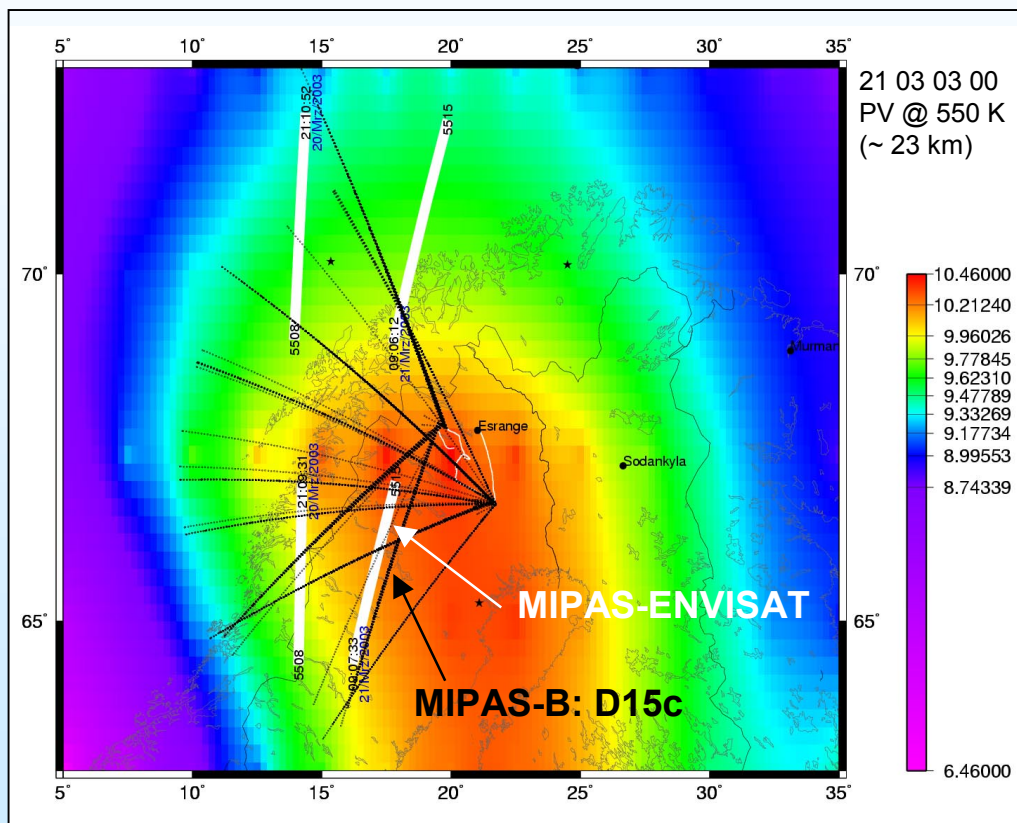
## MIPAS-B (FTIR) - Balloon (Mar. 2003)

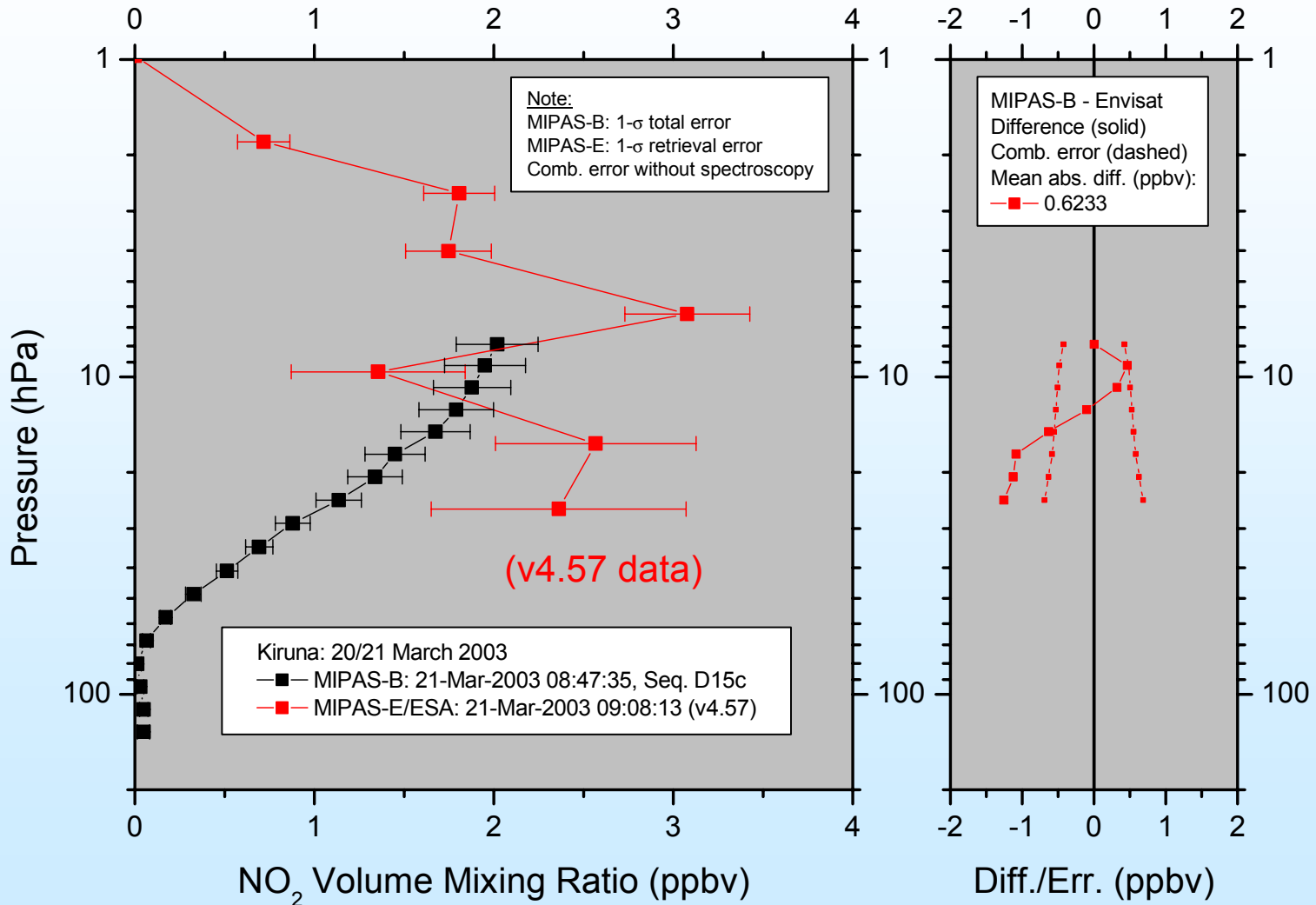
Late arctic winter (morning),  
Kiruna, 68°N, 20/21 Mar.2003:  
Match of ENVISAT evening (orbit: 5508)  
and morning overpasses (orbit: 5515).

Problem: No reprocessed operational data  
(v4.61) available so far!  
Comparison only for v4.57 data  
for orbit 5515 possible.

mean obs. time/coordinates: (Seq. D15c):  
MIPAS-B: 08:48 UT 65.6°N, 17.5°E  
MIPAS-E: 09:08 UT 65.6°N, 17.1°E

→ Perfect coincidence in terms of  
time and location





## SAOZ (UV-vis spectroscopy) - Balloon

(courtesy: F. Goutail, J.-P. Pommereau)

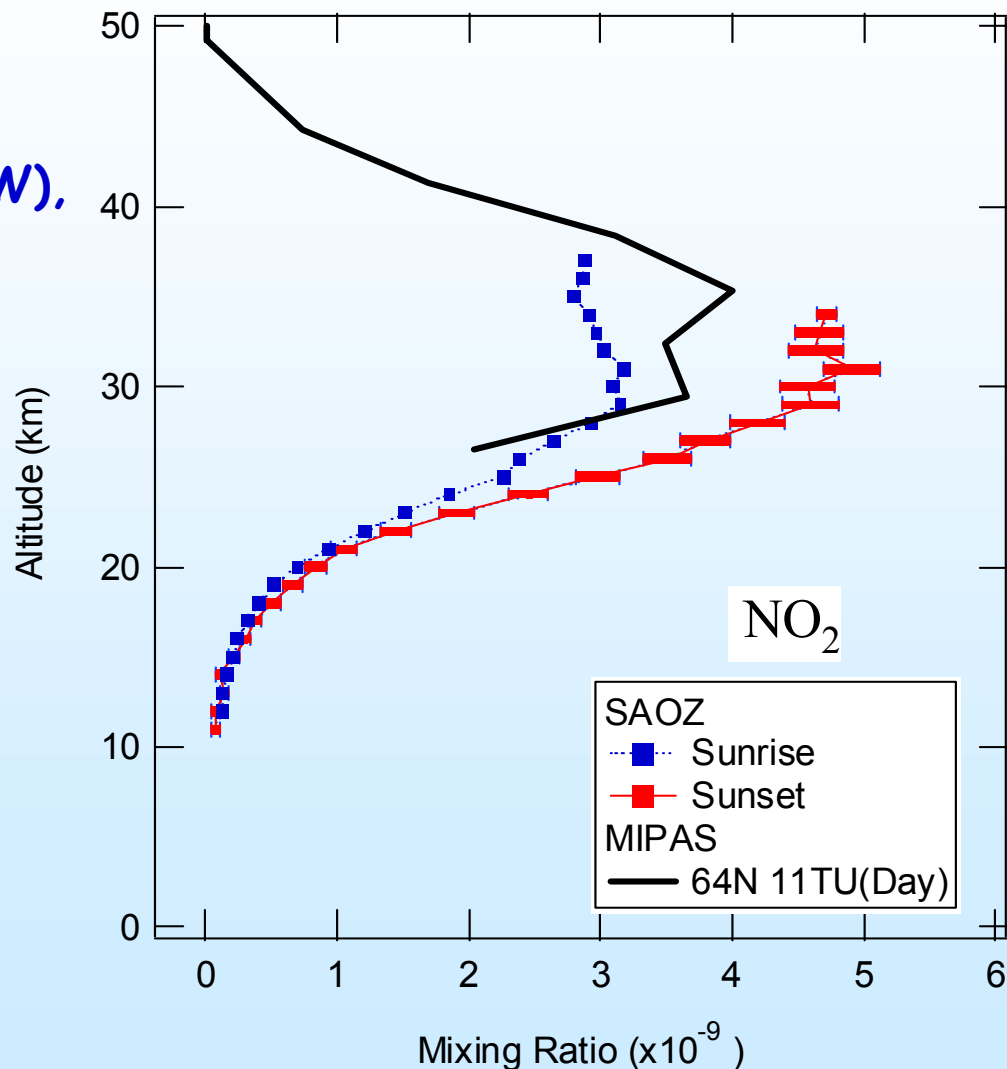
(AOID 701, Service d'Aéronomie, CNRS/IPSL, France)

- 11 SAOZ flights (Aug. 2002 → Feb. 2004)
- Three latitude regions (arctic, mid-latitudes, tropics)
- Various seasons (summer, winter inside and outside vortex)
- Coincidence criteria: 600 km, 4 h
- Only one coincidence found in data base
  
- SAOZ precision for NO<sub>2</sub>: 10% (10-30 km)
- SAOZ converted into mixing ratios using on-board PTU

Vanscoy, Canada (52°N, 100°W),  
Sep. 4, 2002

SAOZ: sunrise and sunset  
MIPAS v4.61: daytime

Future work:  
Model to be used for  
NO<sub>2</sub> diurnal correction.



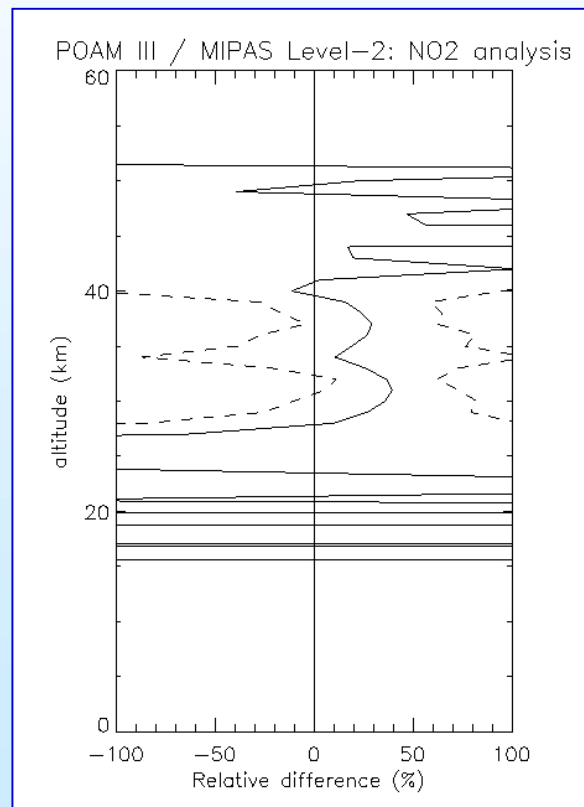
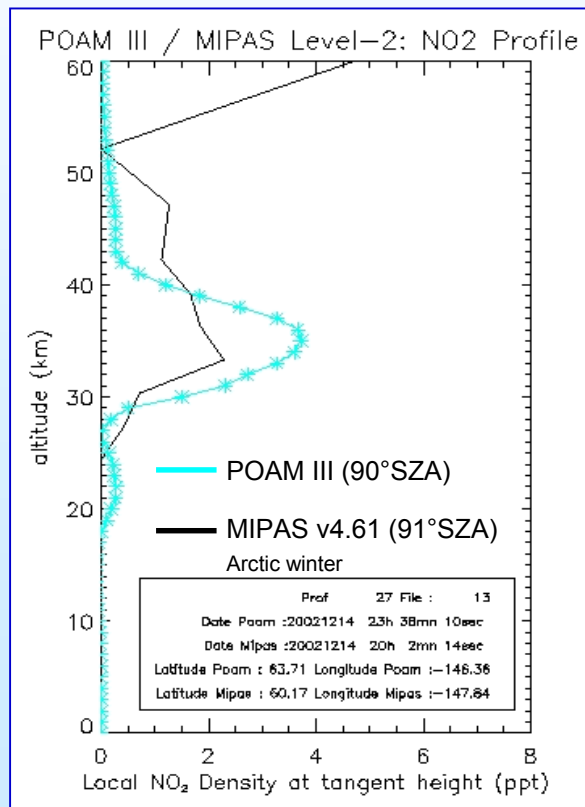
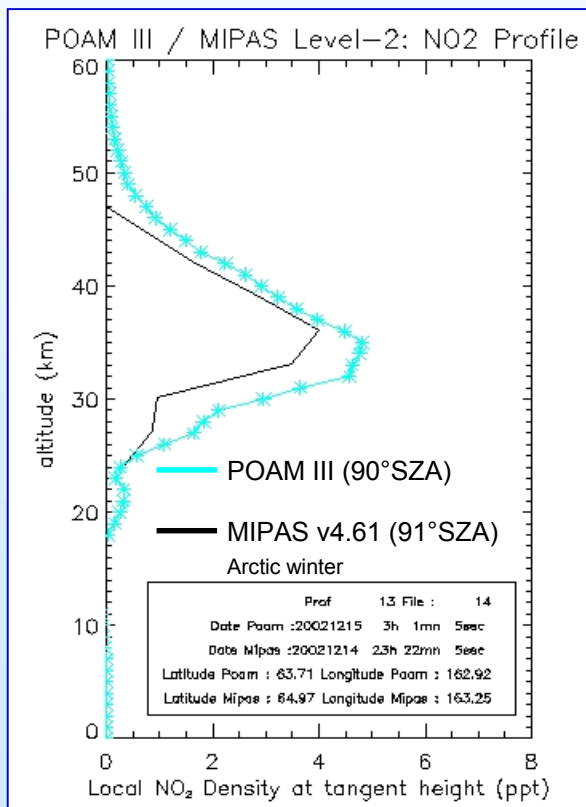
## POAM III (solar occ.) - SPOT-4 sat. (courtesy: F. Goutail, A. Bazureau)

(AOID 317, Service d'Aéronomie, CNRS/IPSL, France)

- One latitude region:  $60^{\circ}$ - $70^{\circ}$ N
- Two periods: Aug. - Sep. 2002 → 112 coincidences  
Oct. - Dec. 2002 → 57 coincidences
- Coincidence Criteria: 600 km, 4 h
  
- POAM III precision for  $\text{NO}_2$ :  $< 10\%$  (20-45 km)
- POAM III converted into mixing ratios using NMC analyses

## Northern Hemisphere Oct-Dec 2002 (57 profiles)

- Direct coincidence in terms of latitude/longitude and time is alright
- Quality of agreement is variable (e.g. altitude shift in some MIPAS profiles)
- Positive bias (20%) between POAM III and MIPAS (27-40 km), "high quality" profiles

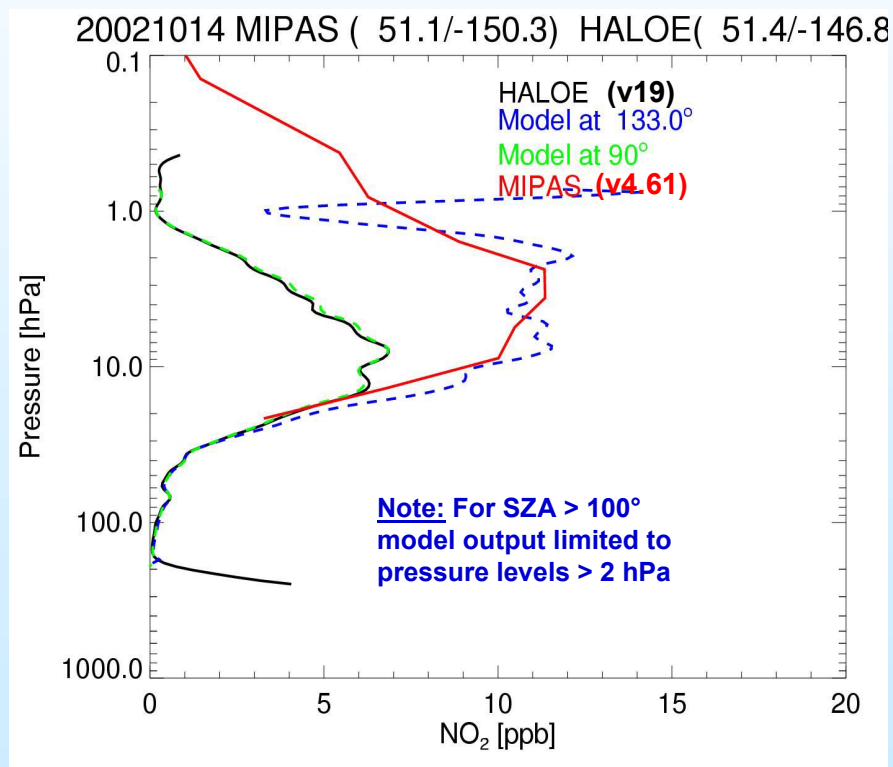


# HALOE (solar occ., v19 data) - UARS satellite

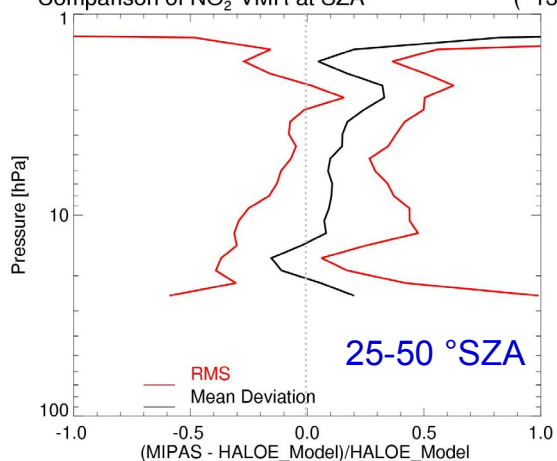
(courtesy: A. Bracher, M. Sinnhuber, M. Weber, K. Bramstedt)

(AOID 651, Institute of Environmental Physics, University of Bremen, Germany)

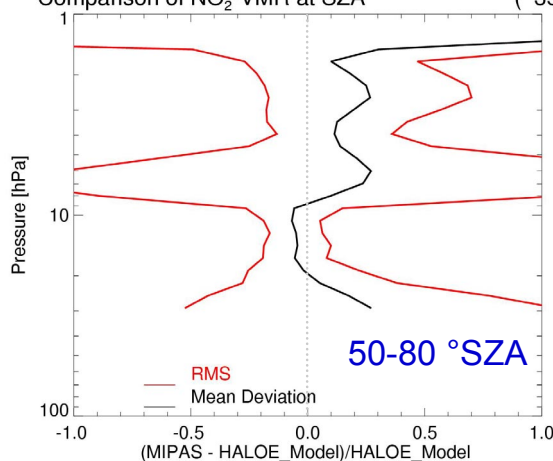
- ☞ Solar zenith angle (SZA) of HALOE  $\sim 90^\circ$  (occultation instrument,  $\text{NO}_2$  acc. 15% at 25-45 km), MIPAS variable SZAs  
 → photochemical corr. of  $\text{NO}_2$  necessary
- ☞ HALOE  $\text{NO}_2$  used as input for 1-D photochemical model and scaled to MIPAS SZA (described in Bracher et al., subm. to ACP)
- ☞ HALOE within 250 km of MIPAS observations during the same day
- ☞ 93 collocations for validation reference set (24 Jul. - 14 Dec. 2002)  
 most at  $30^\circ\text{N} - 60^\circ\text{N}$  (42),  
 $60^\circ\text{N} - 90^\circ\text{N}$  (29),  
 2 in the tropics,  
 10 at  $> 30^\circ\text{S}$



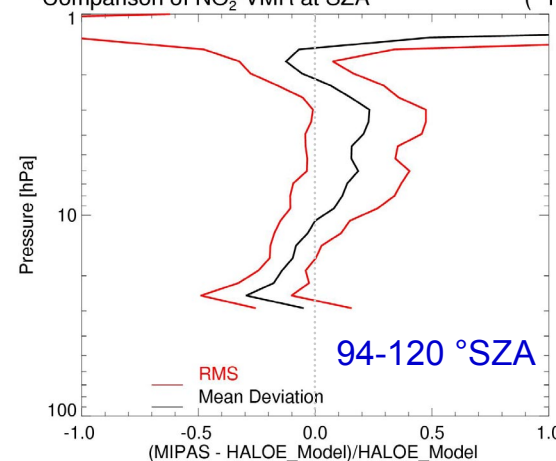
Comparison of NO<sub>2</sub>-VMR at SZA ( 13)



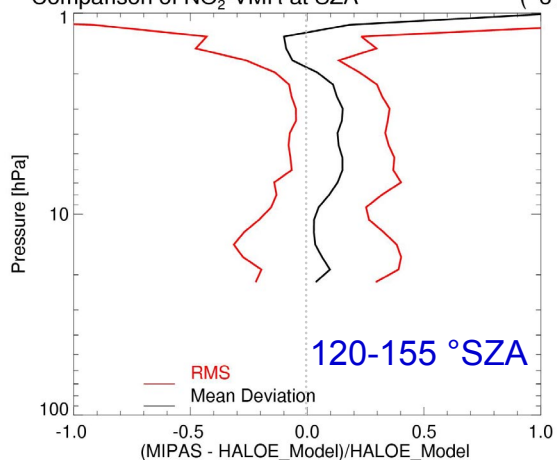
Comparison of NO<sub>2</sub>-VMR at SZA ( 35)



Comparison of NO<sub>2</sub>-VMR at SZA ( 14)



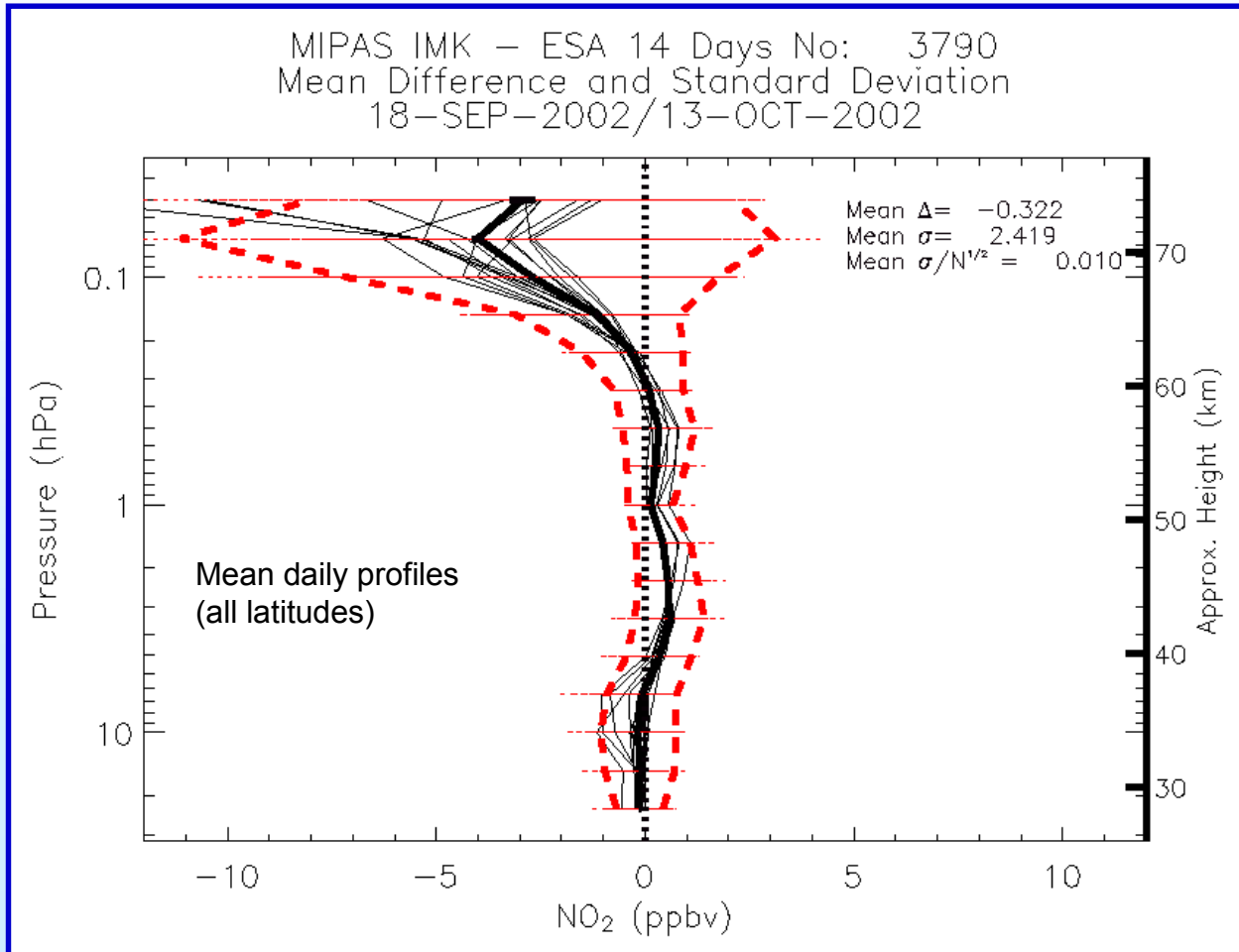
Comparison of NO<sub>2</sub>-VMR at SZA ( 31)



Statistics for all comparisons of MIPAS v4.61 to model with HALOE-input at different MIPAS SZAs:  
(MIPAS - HALOE\_Model)/HALOE\_Model

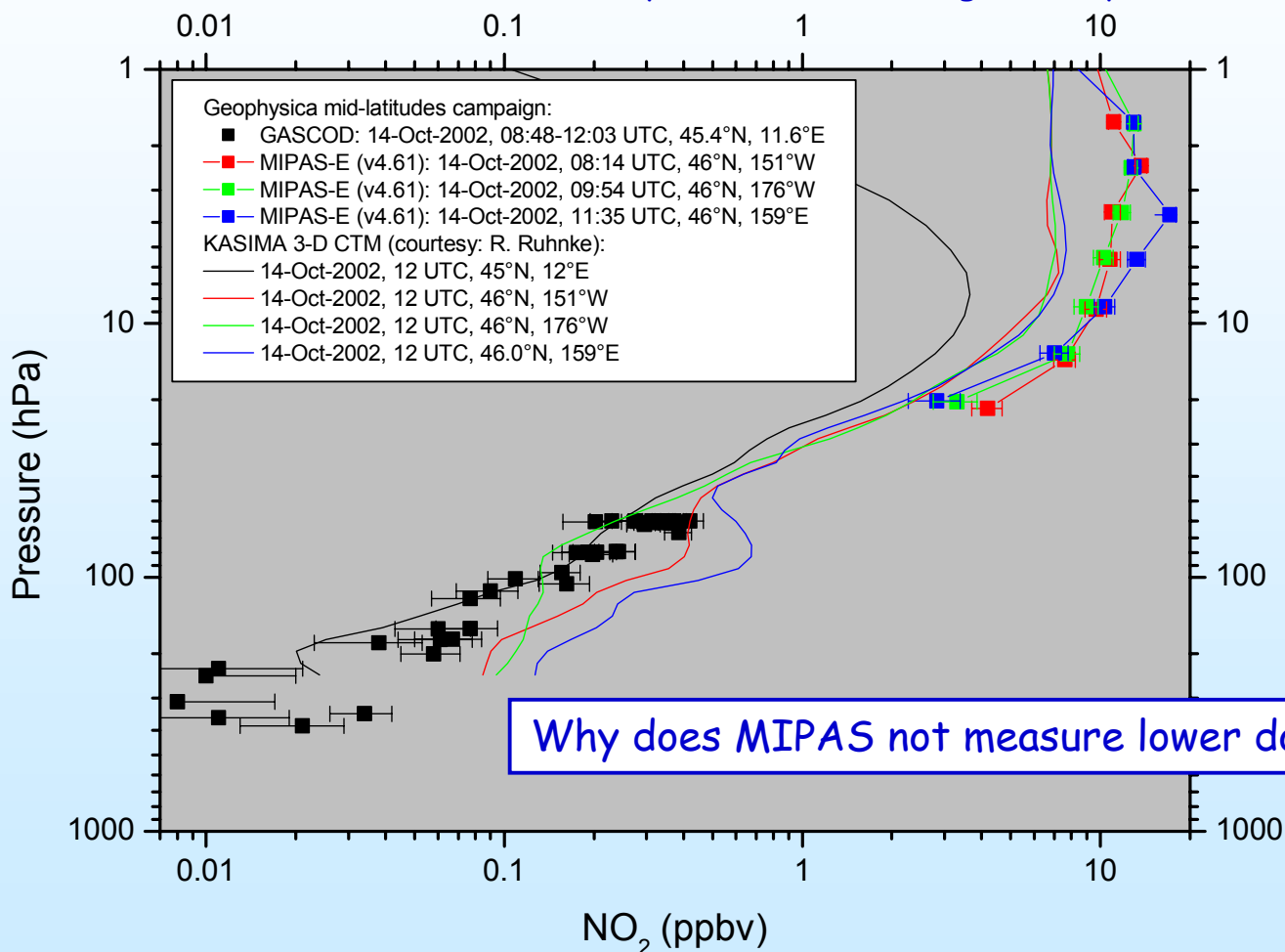
MIPAS SZA	mean rel. deviation	RMS	n
25°-50°	at 1.5 - 25 hPa -15 → +30%	30%	13
50°-80°	at 1.5 - 25 hPa - 8 → +25%	40%	35
	(at 5.5 - 8.5 hPa	>100%!	
94°-120°	at 1.5 - 25 hPa -15 → +30%	30%	14
120°-155°	at 2 - 25 hPa -10 → +15%	30%	31

**MIPAS/E-IMK (V1/4.55) vs. MIPAS/E (v4.61)** (courtesy: B. Funke, D.Y. Wang)  
 (IAA, Granada, Spain; IMK-ASF, Karlsruhe, Germany)



# GASCOD (in-situ) - Geophysica (courtesy: A. Martinez, I. Kostadinov)

(ERS-Srl, Florence, Italy; ISAC-CNR, Bologna, Italy)



Why does MIPAS not measure lower down?

## Ground-based FTIR in Kiruna (courtesy: T. Blumenstock)

(IMK-ASF, Karlsruhe, Germany)

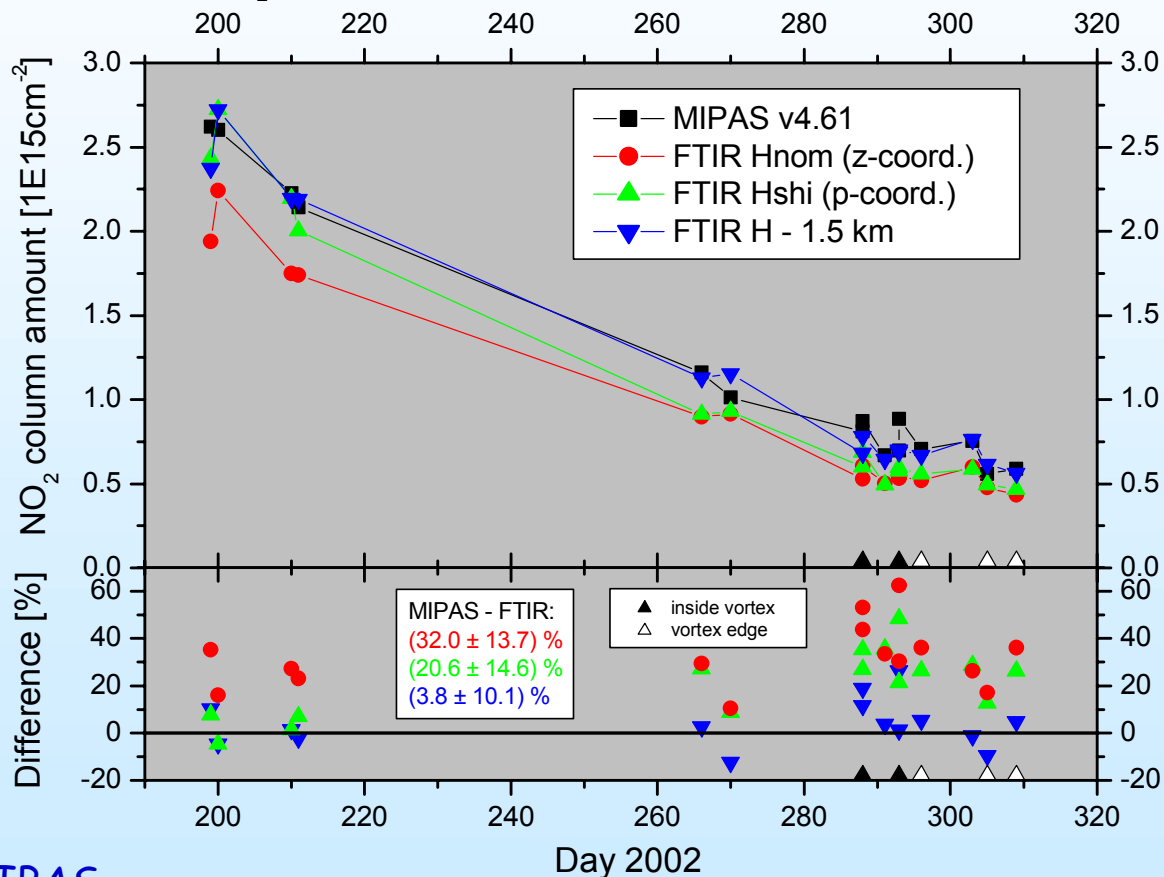
### Kiruna (NDSC station):

morning overpasses,  
~ 8.00 - 10.00 UT

Lowest  $z_{\min}$ : ~ 25 km

- ~ 40 % of total column subtracted
- g.b. result is strongly dependent on lowest stratosph. altitude and the partial column below
- MIPAS partial columns are larger compared to g.-b. measurements
- Seasonal variation is captured fairly well by MIPAS

MIPAS v4.61 NO<sub>2</sub> column amounts vs. g.-b. FTIR at Kiruna (18 Jul. - 5 Nov. 2002)



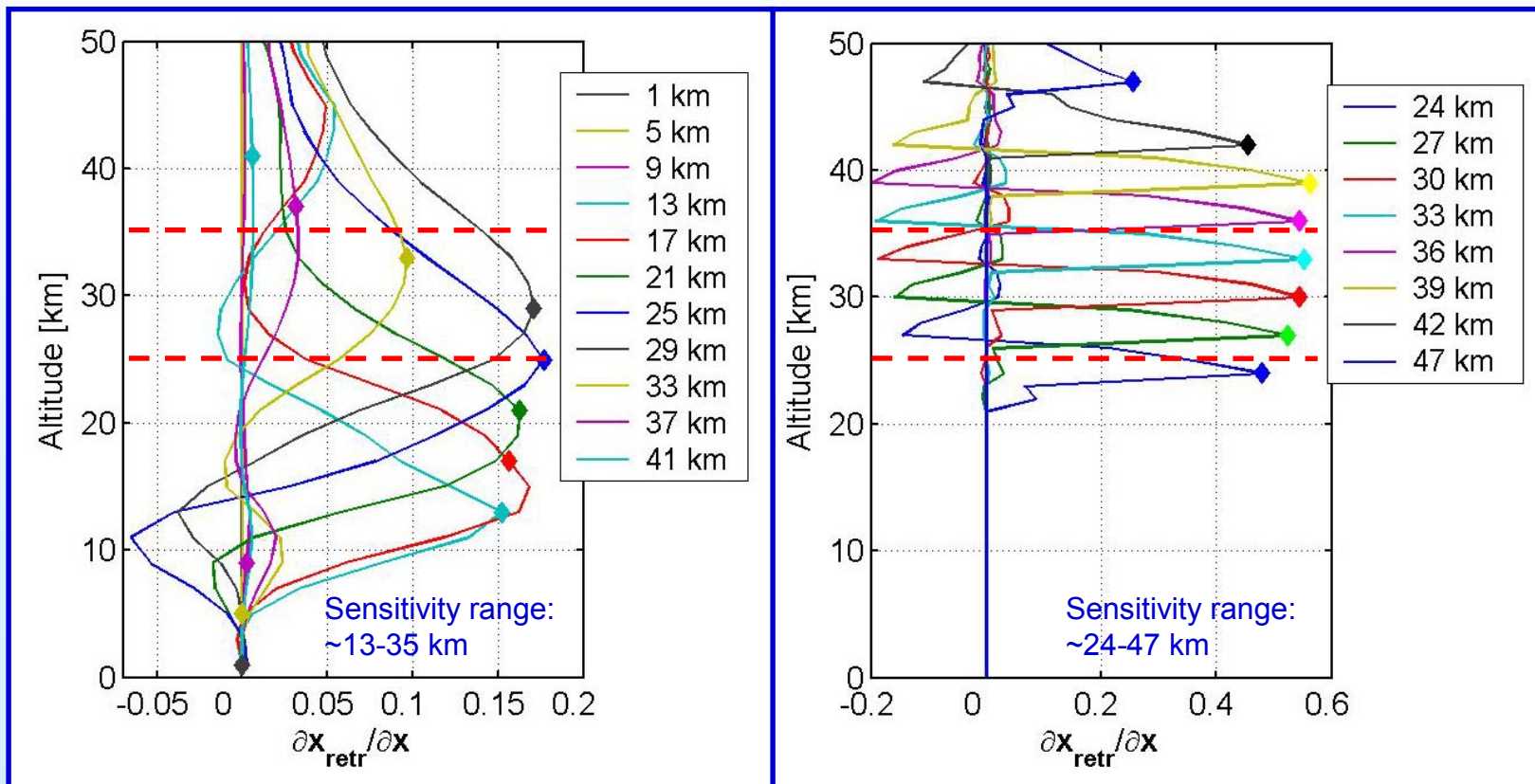
## G.-b. UV-vis spectr. at the NDSC station Harestua (60°N)

(courtesy: F. Hendrick, M. Van Roozendael, M. De Mazière)

(Belgian Institute for Space Aeronomy, Brussels, Belgium)

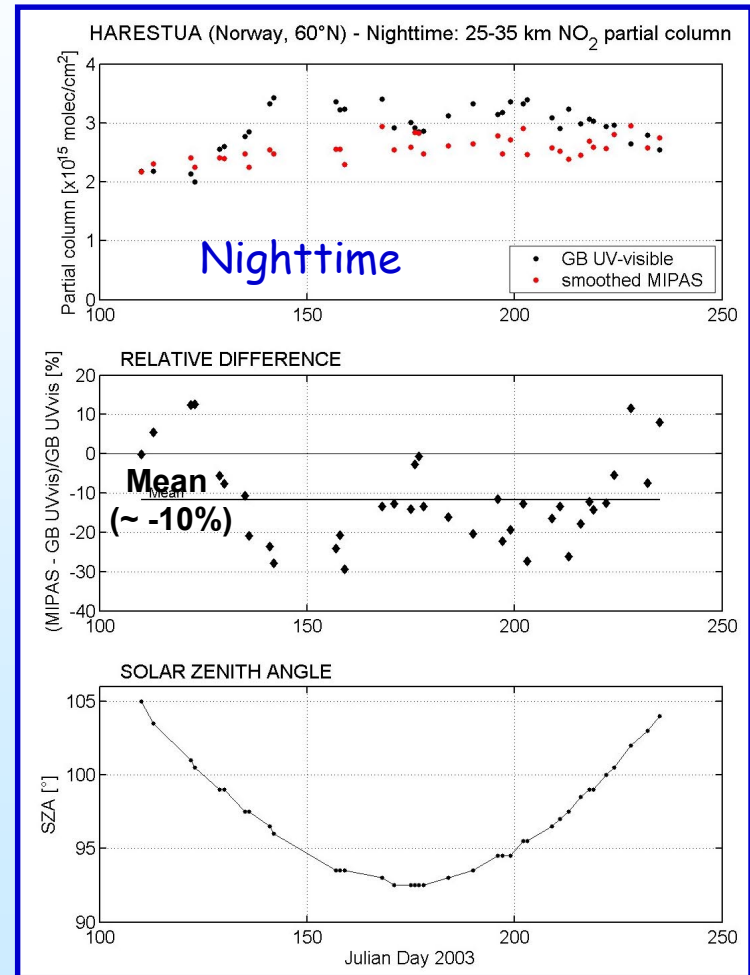
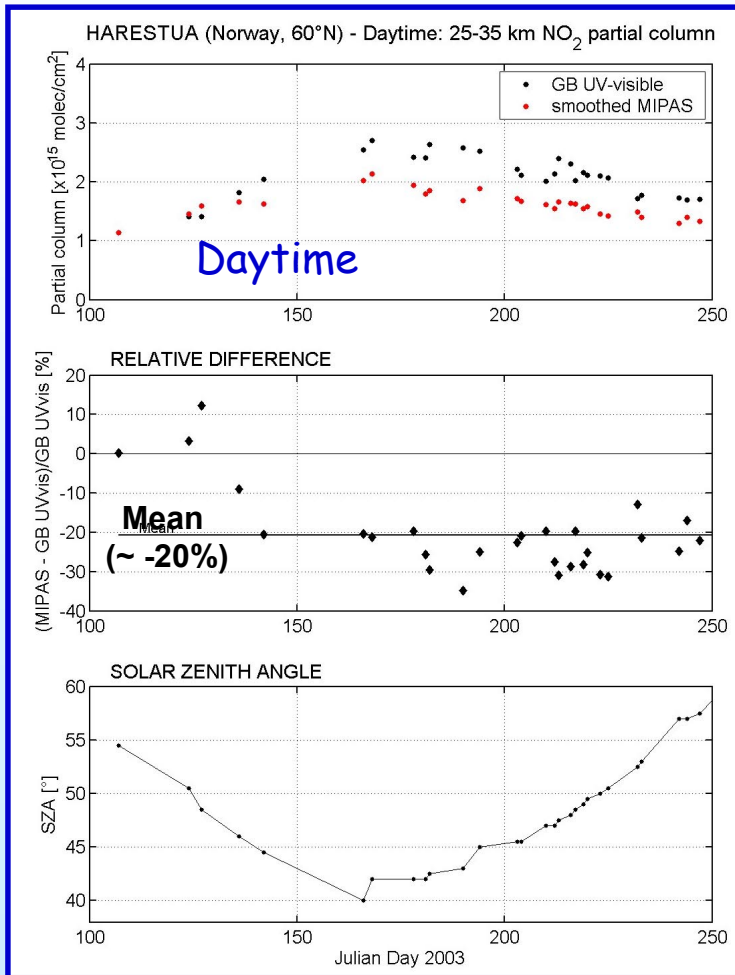
- ☞ IASB-BIRA zenith-sky UV-vis spectrometers continuously operating since 1998
- ☞ Retrieval technique (optimal estimation [Rodgers, 2000]) is based on dependence of mean scattering height on solar zenith angle (SZA) [Preston et al., 1997], thoroughly validated by correlative measurements [Hendrick et al., submitted to ACPD, 2004]
- ☞ Stacked box photochemical model is included in the retrieval algorithm in order to reproduce the effect of the rapid variation of the NO<sub>2</sub> concentration at twilight
- ☞ Comparison with MIPAS NO<sub>2</sub> v4.57 and v4.59 for the period April-August 2003
- ☞ Criteria for the selection of coincident events:
  - Spatial: - Distance from the Harestua station < 500 km
  - Temporal: - Days of MIPAS observations = days of ground-based UV-visible obs.
  - Comparisons performed at the same SZA: ~ 40-60° for daytime and ~ 95-105° for nighttime conditions according to the MIPAS overpasses in the April-August period
- ☞ Number of coincident events: 28 at daytime, 37 at nighttime

## Ground-based UV-visible and MIPAS NO<sub>2</sub> averaging kernels:



→ 25-35 km is the altitude range where the comparison is relevant; smoothing of the MIPAS profiles is needed for the comparison

# 25-35 km partial columns comparison (MIPAS v4.57 & 4.59)



## Conclusions

- ➔ Inter-comparison aggravated by
  - Diurnal variation of NO<sub>2</sub>, especially for measurements around SR and SS
  - Lack of reprocessed v4.61 data for 2003
- ➔ Validation results obtained so far (quality rating: ++ very good, + good, ○ fair, ? unclear)
  - Balloon
    - SPIRALE Sep./Oct. 2002 mid-latitudes ++
    - MIPAS-B Sep. 2002 mid-latitudes ++
    - SAOZ Sep. 2002 mid/high-lat. + ?
  - Satellite
    - POAM III Aug.-Dec. 2002 high-latitudes ○ low bias in MIPAS (20%, 27-40 km)
    - HALOE Jul.-Dec. 2002 all latitudes ++ high bias in MIPAS (~5%, 1.5-25 hPa)
    - MIPAS-IMK Sep./Oct. 2002 all latitudes ++ between 20 and 0.2 hPa
  - Aircraft
    - GASCOD Oct. 2002 mid-latitudes ? no alt. match, qualitatively reasonable
  - Ground-based
    - FTIR Kiruna Jul.-Nov. 2002 high latitudes + high bias in MIPAS (4-20%)
    - UV-vis Har. Apr.-Aug. 2003 mid/high lat. ○ low bias in MIPAS (v4.5x, 10-20%)
- ➔ Apart from retrieval instabilities (v4.61) NO<sub>2</sub> looks reasonable (25-45 km)
- ➔ Some high biases (MIPAS) in IR comp. and low biases in Uv-vis comp. visible