VALIDATION OF MIPAS OPERATIONAL LEVEL 2 PRODUCTS USING GROUND-BASED NETWORK DATA

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Structure of talk

What can be achieved as to validation of MIPAS constituent profiles, using ground-based network data

- for O_3 ? for other species ? -

- network:

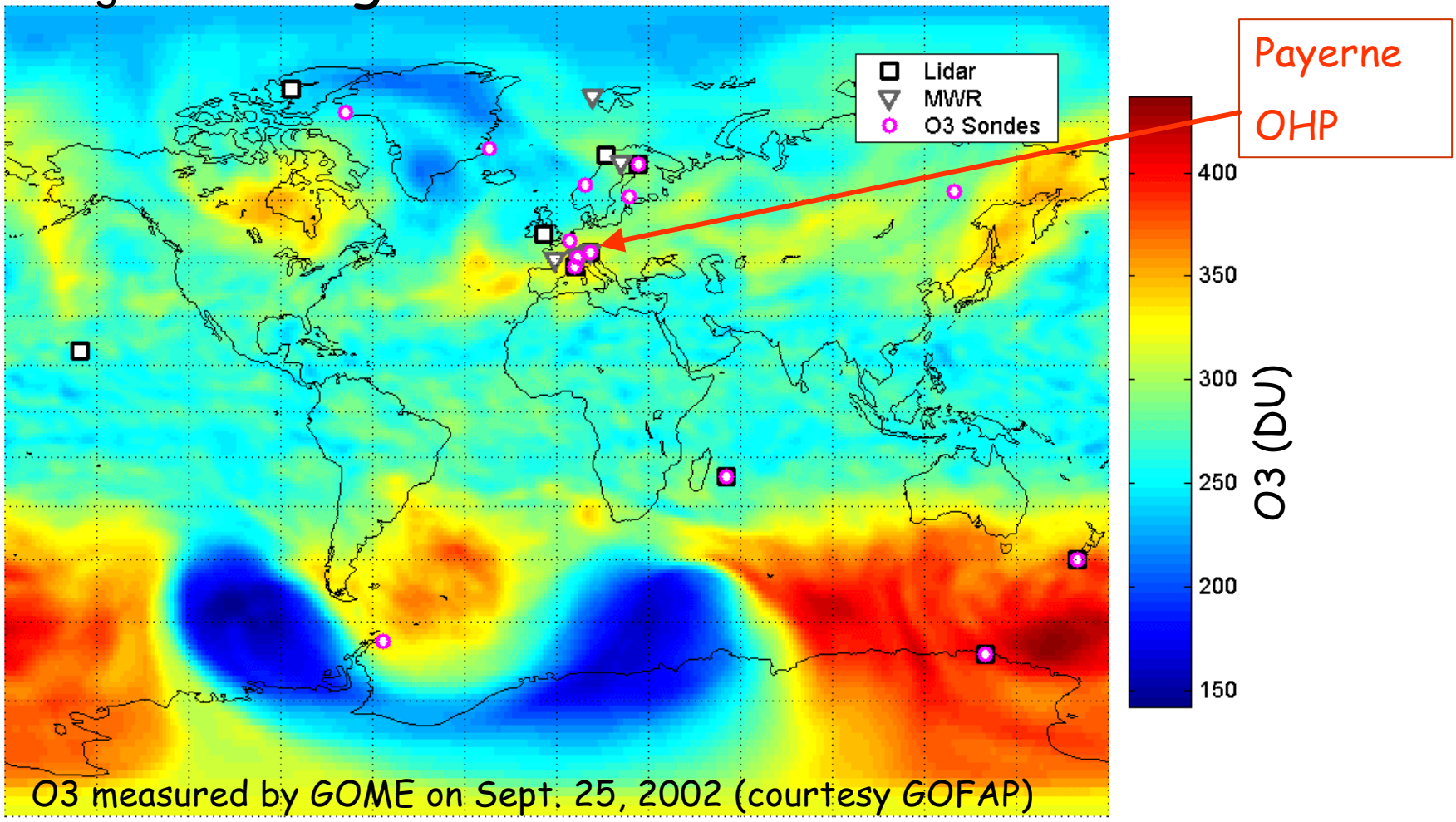
  coverage, instruments and capabilities

- from high vertical resolution to low-vertical resolution intercomparisons

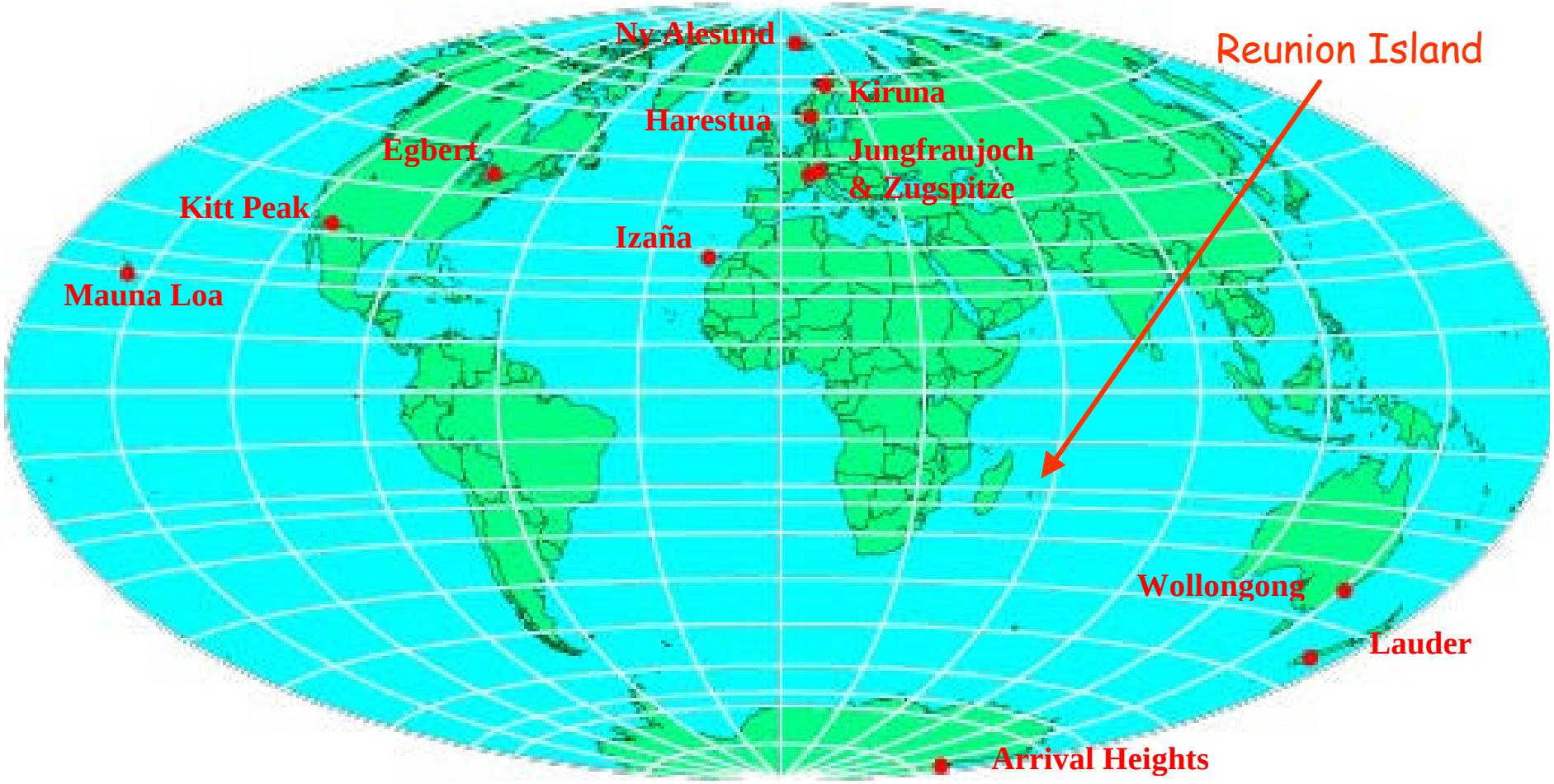
  challenges and future perspectives

Ground-based network

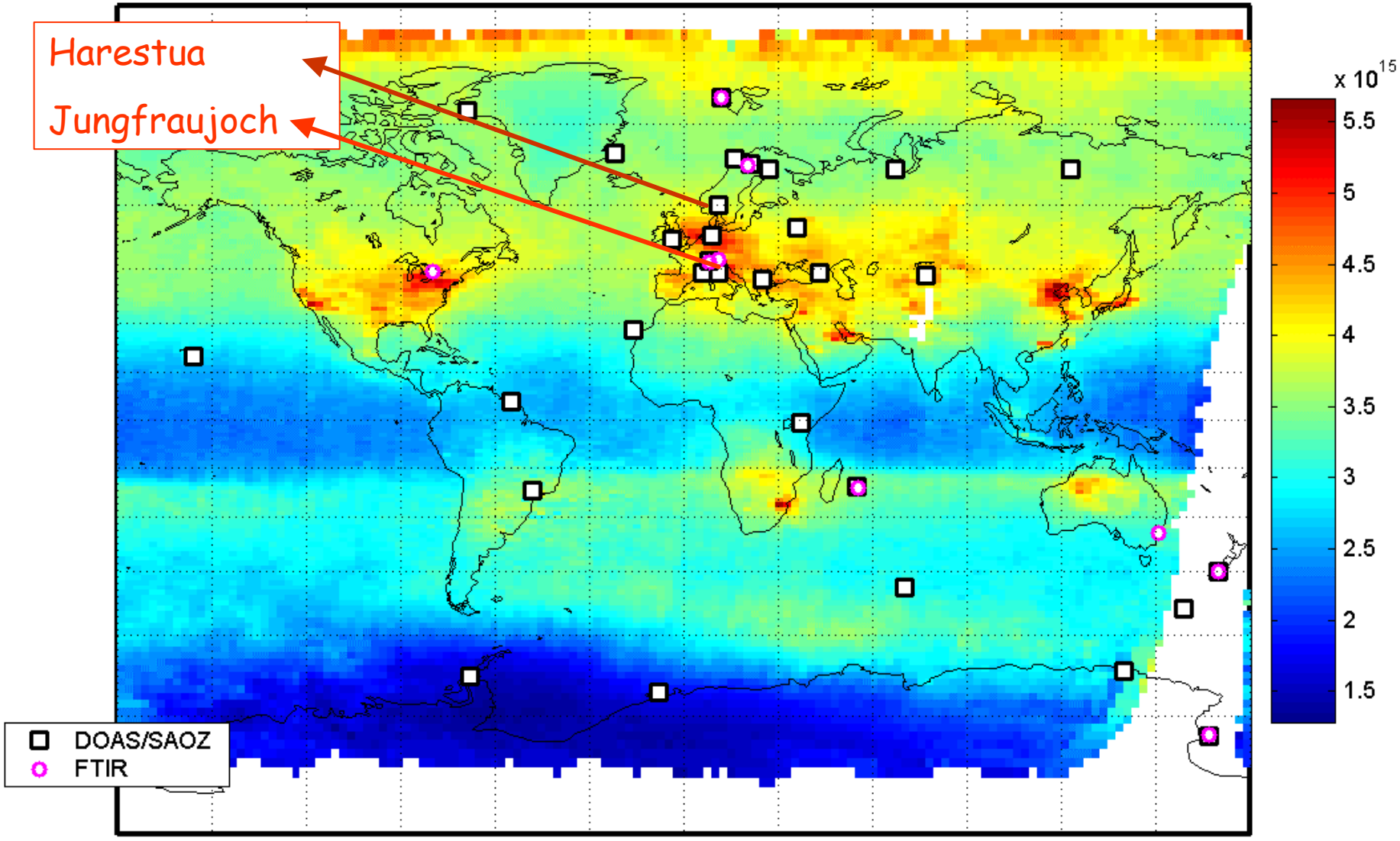
O_3 sounding instruments



FTIR instruments NDSC & campaign basis



UV-VIS DOAS instruments (NDSC)



O_3

Wealth of correlative data:

- O_3 sondes :

(0-) 30 km range; Dz ~ 100 m

- Lidar data :

15 - 40 km range; Dz ~ 1.5 km ® 4 km

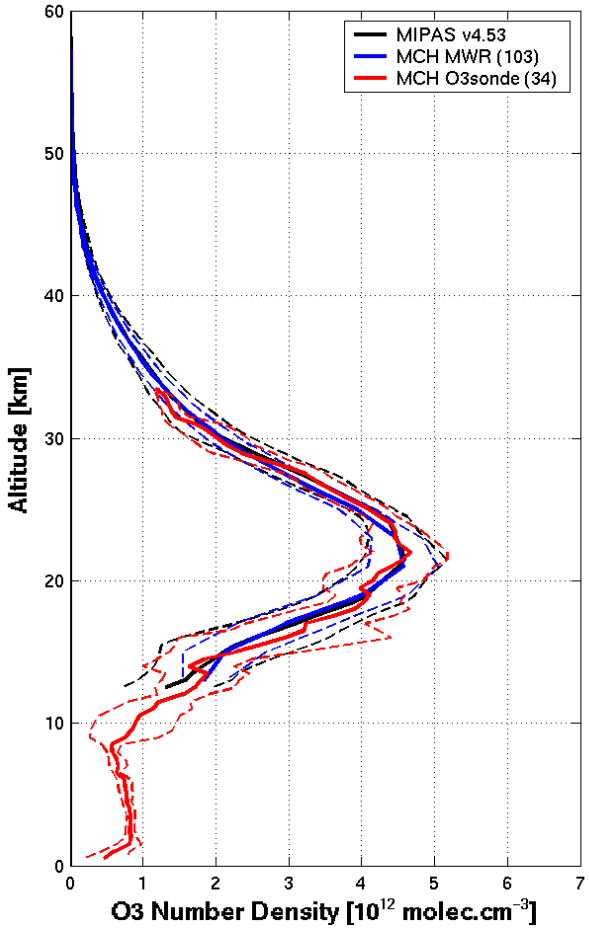
- Microwave radiometer (MWR) data :

20 - 60 km range; Dz ~10 km

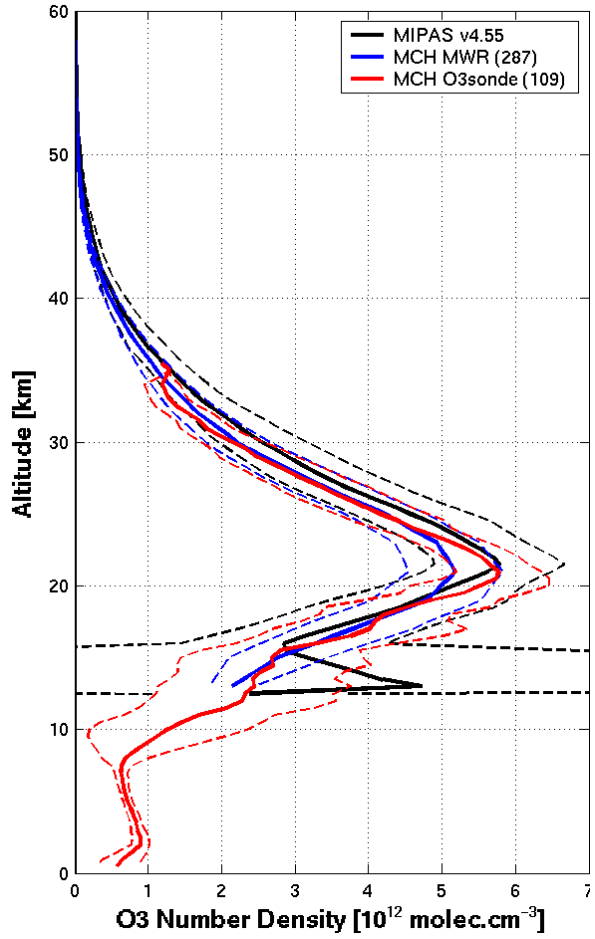
☞High vertical resolution intercomparisons up to 40 km

Results at Payerne (46.5°N-6.6°E): MIPAS V4.53 vs 4.55

Coincidences 14/11/2002-16/12/2002

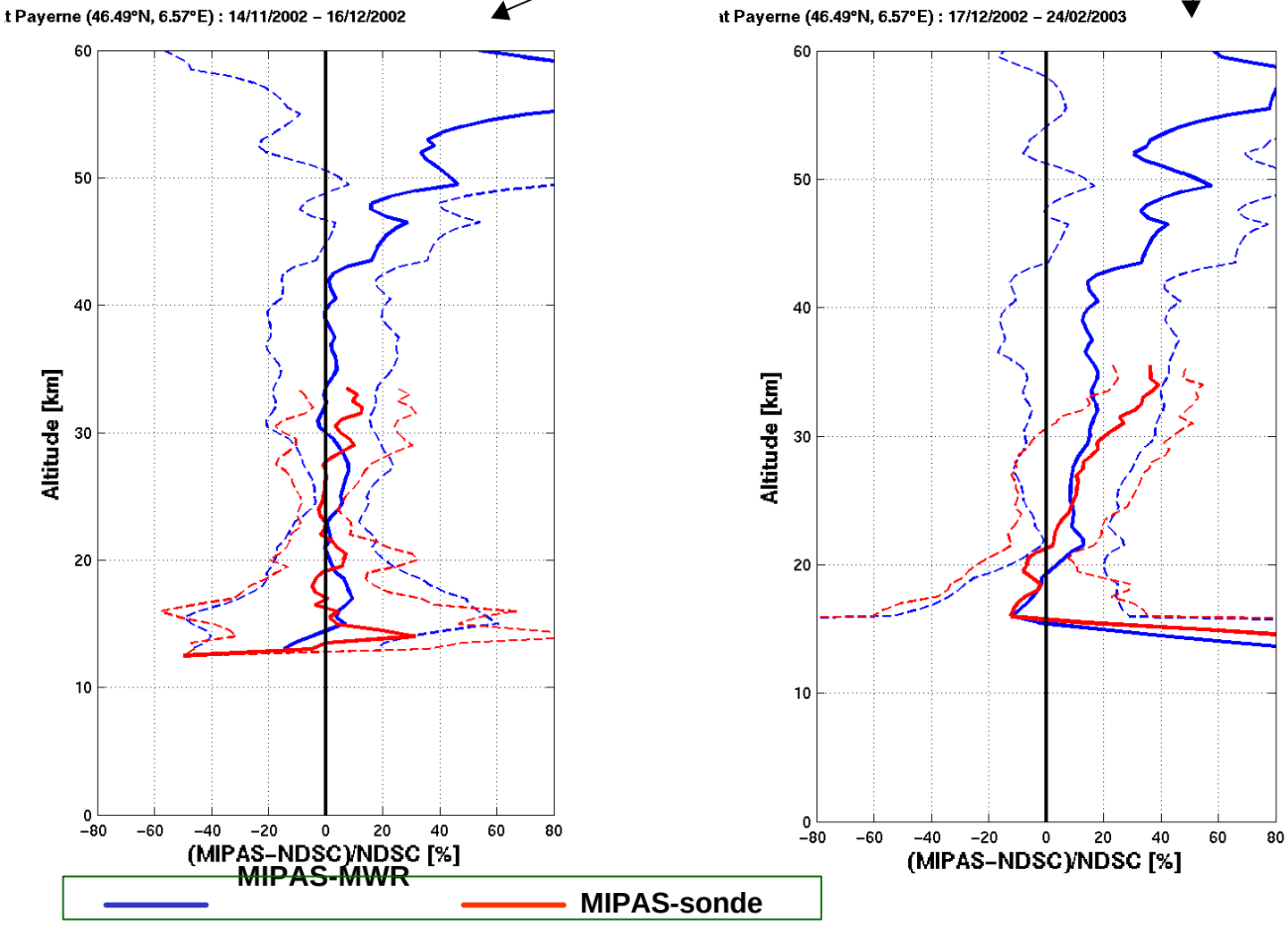


17/12/2002-24/02/2003



Caveat...

Relative differences for v4. 53 and v4.55



NO_2

Most appropriate instruments for ***NO_2*** are UV-VIS Zenith-sky DOAS Instruments

observations of scattered sunlight at twilight

- NO_2 morning (am) and evening (pm) slant column measurements

- *Recently*: inversion of low resolution profiles, based on dependence of scattering height on solar zenith angle (SZA)

☞ Low vertical resolution intercomparisons, taking into account diurnal variation of NO_2 (SZA dependence)

Retrieval of vertical profile information from UV-vis observations

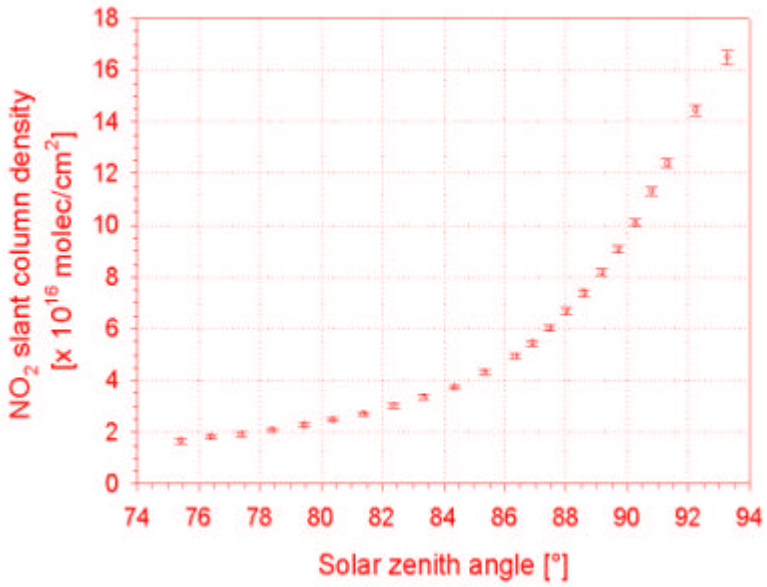
Based on the work of Preston et al, 1997

$$\mathbf{y} = F(\mathbf{x},\mathbf{b}) + e_y$$

e_y: Measurements errors

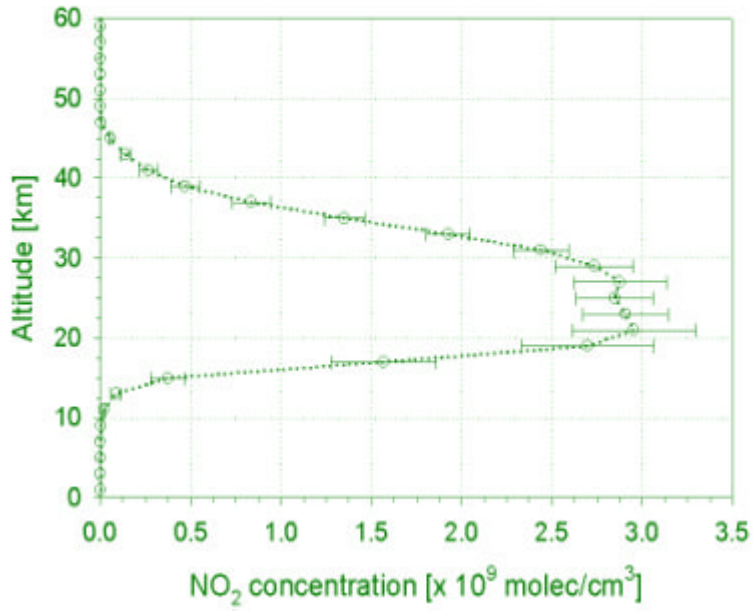
b: Vector of forward model parameters

Measurements: slant column densities



Forward model

Vertical profile



Retrieval method: optimal estimation [OEM, Rodgers, 2000]

$$\mathbf{x}_{retr} = \mathbf{x}_a + \mathbf{S}_a \mathbf{K}^T (\mathbf{K}\, \mathbf{S}_a \mathbf{K}^T + \mathbf{S}_\varepsilon)^{-1} (\mathbf{y} - \mathbf{K}\, \mathbf{x}_a) \text{ with } \mathbf{x}_a = \text{a priori}$$

Forward model

Stacked box photochemical model PSCBOX [Errera and Fonteyn, 2001]

- 48 species, 110 gas-phase, and 31 photolysis reactions
- Heterogeneous chemistry processes on PSCs and aerosols particles included
- Full diurnal cycle, no family and photochemical equilibrium assumptions
- Kinetic and photochemical data from JPL 2000 [Sander et al., 2000]
- Initialisation: 12h UT 3D-CTM SLIMCAT (P, T + 32 species; 18 altitude levels)

Radiative transfer model UVspec/ DISORT [Kylling, 1995]

- Discrete-ordinate, 10 streams, pseudo-spherical approximation
- Accounts for 2-D chemical variation of NO_2 profiles (incident beam)
- Accounts for multiple scattering, ground albedo and aerosol scattering

Results at Harestua

- 60°N, 10°E; NDSC complementary station, often in vortex edge
- UV-VIS DOAS zenith-sky instrument operated by BIRA-IASB
- DOAS timeseries since 1998 on a continuous basis
  - NO_2
  - O_3
  - OClO
  - BrO

➪ Comparisons of NO_2 with MIPAS v4.57 for the period April- August 2003

Comparison conditions:

MIPAS overpasses around 9-10 and 21-22 UT,

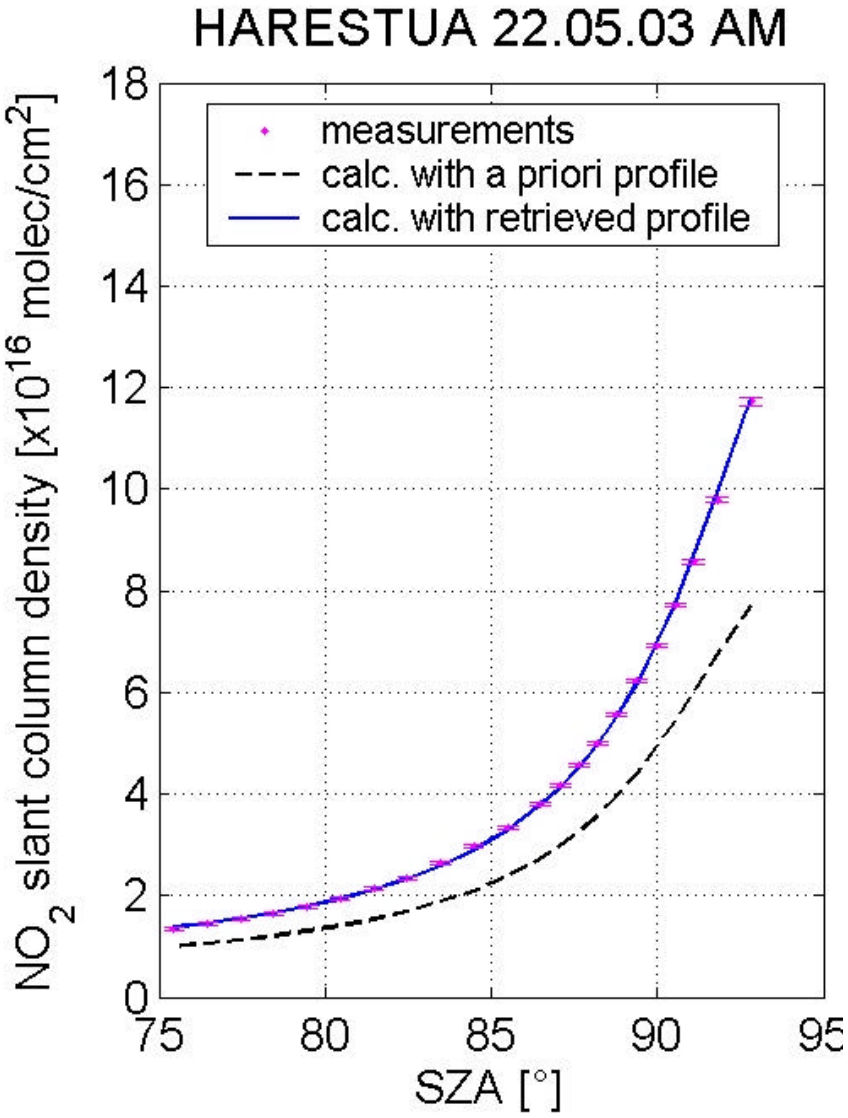
↳ daytime SZA (~40-60°) and nighttime SZA (~95-110°) in April-Aug period

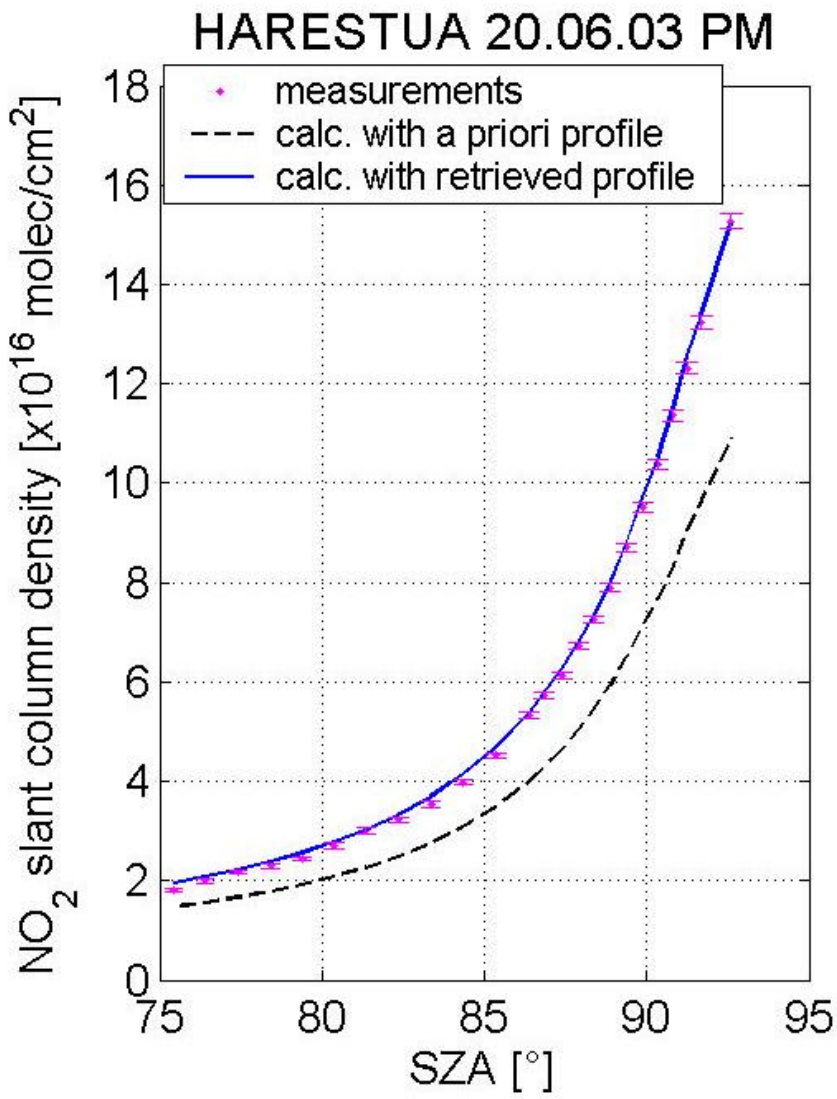
At present, model limited to ~75° to 93°SZA

→ comparisons will not be at exactly same SZA

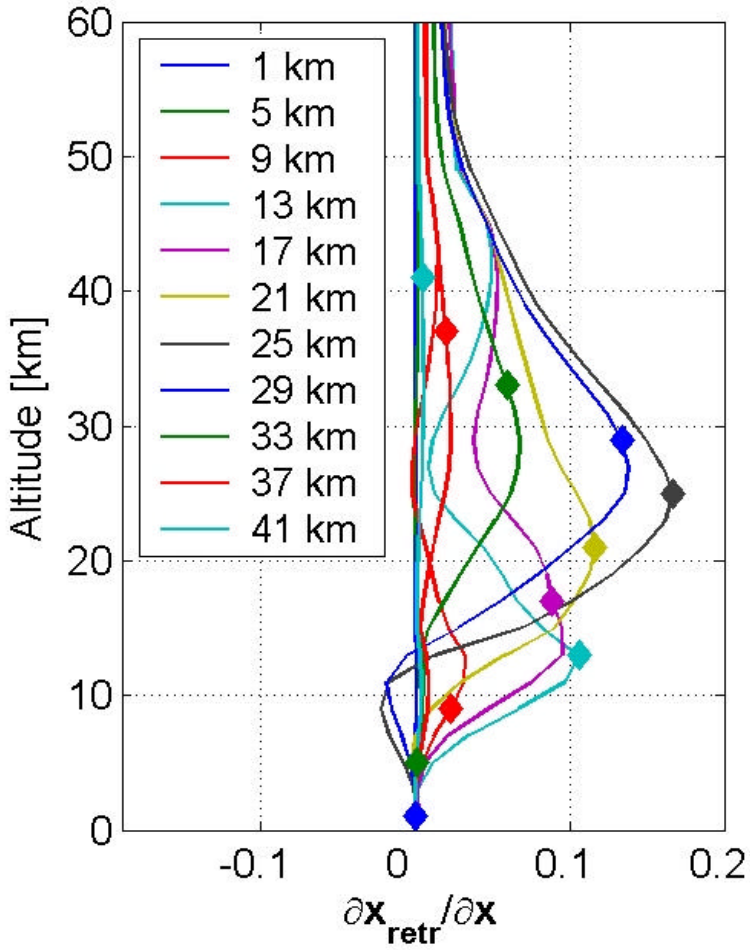
→ To be 'extrapolated'

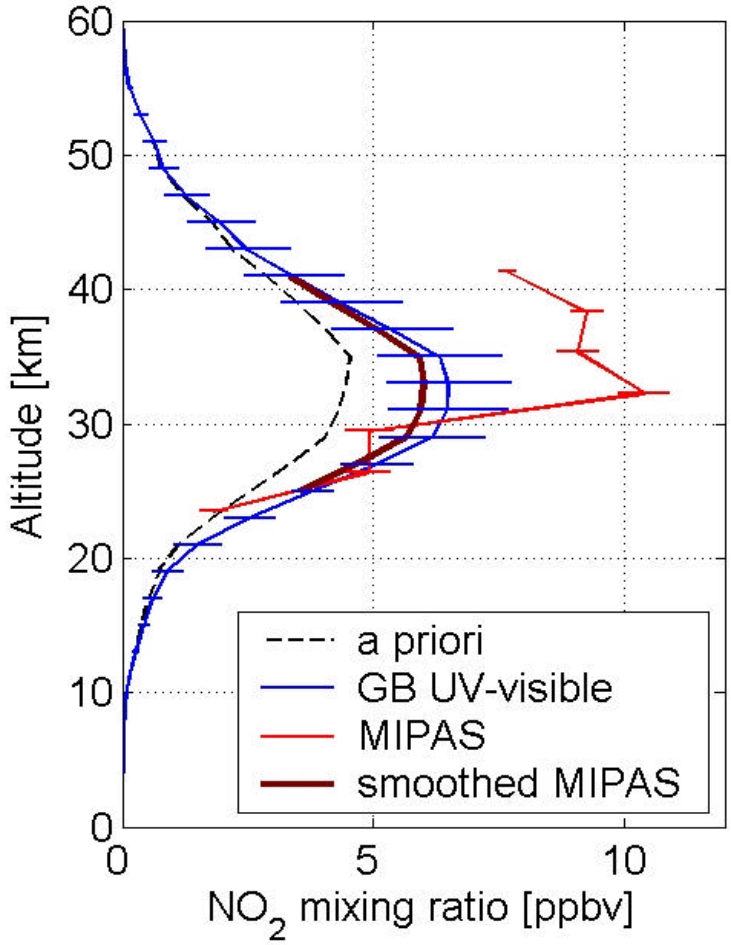
'Fit' results


HARESTUA 22.05.03 AM
measurements
calc. with a priori profile
calc. with retrieved profile
NO2 slant column density [x10^16 molec/cm^2]
SZA [°]
0
2
4
6
8
10
12
14
16
18
75
80
85
90
95


HARESTUA 20.06.03 PM
measurements
calc. with a priori profile
calc. with retrieved profile
NO2 slant column density [x10^16 molec/cm^2]
SZA [°]
0
2
4
6
8
10
12
14
16
18
75
80
85
90
95

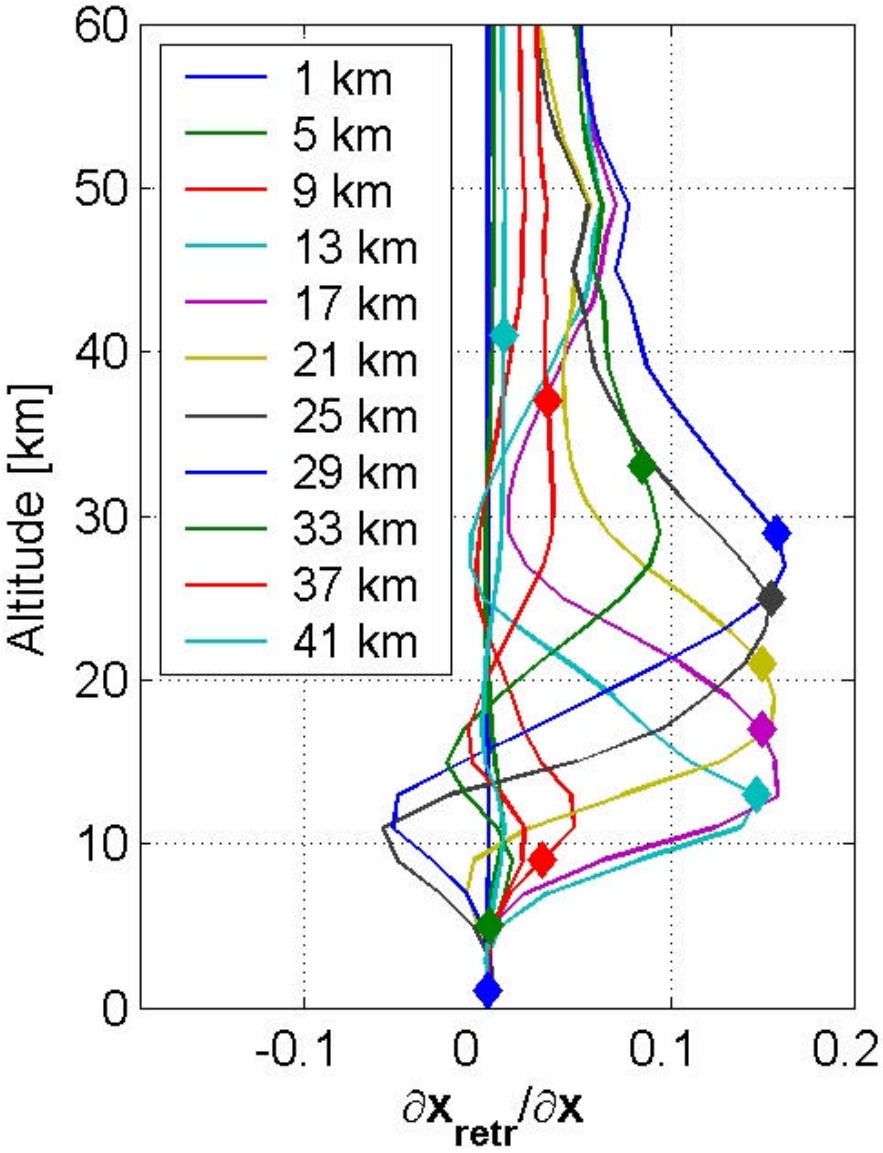
NO_2 typical evening result (20-06-2003 pm):

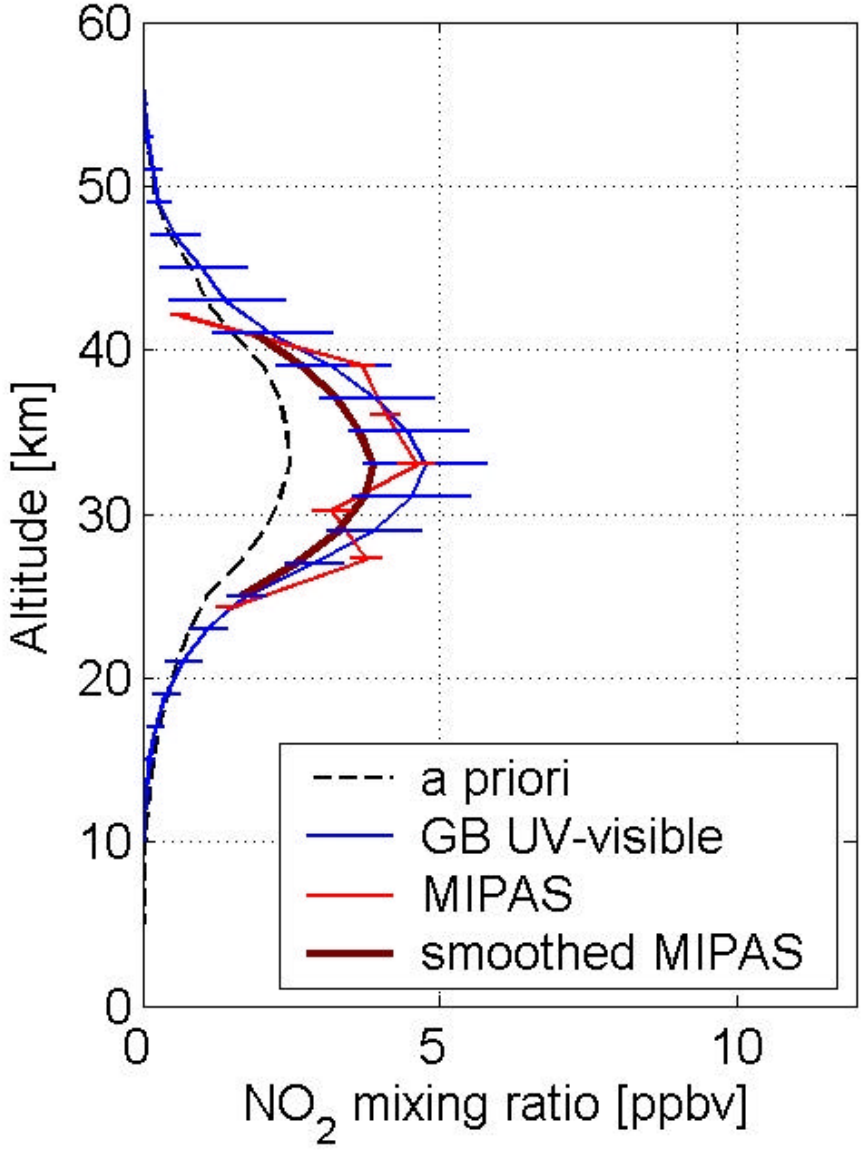


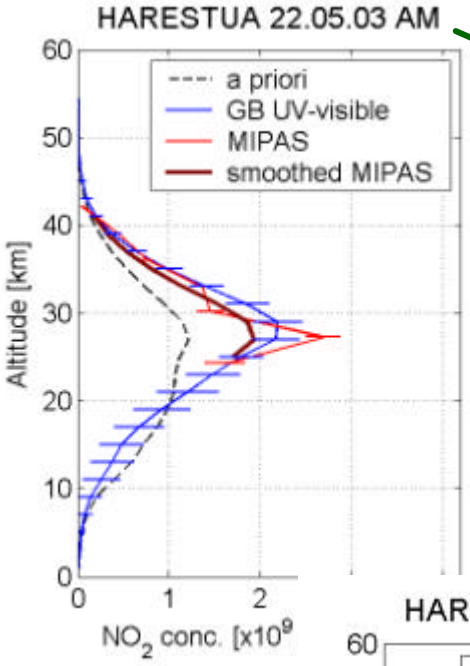


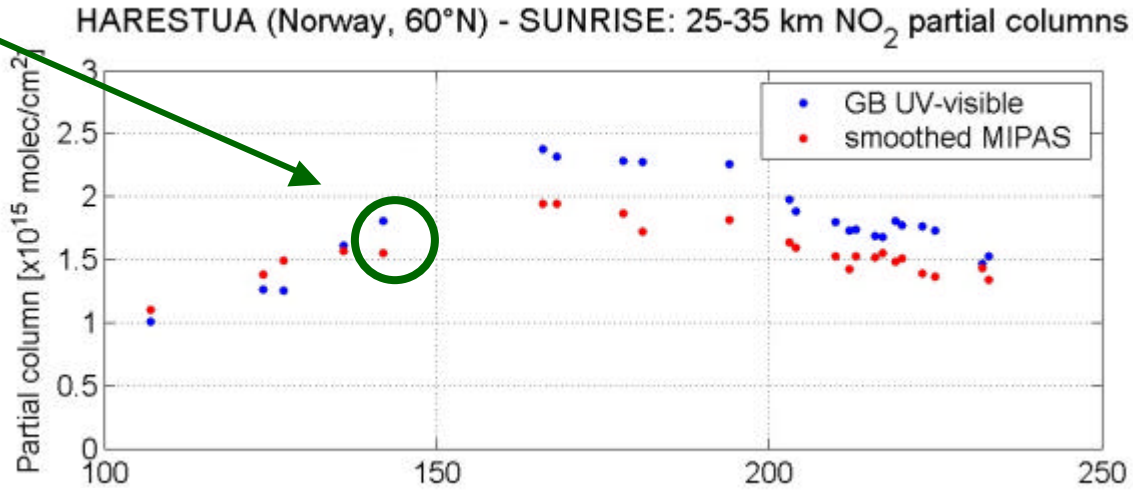
- UV-VIS DOAS inversion sensitive in range 15-35 km
- 2 independent information elements

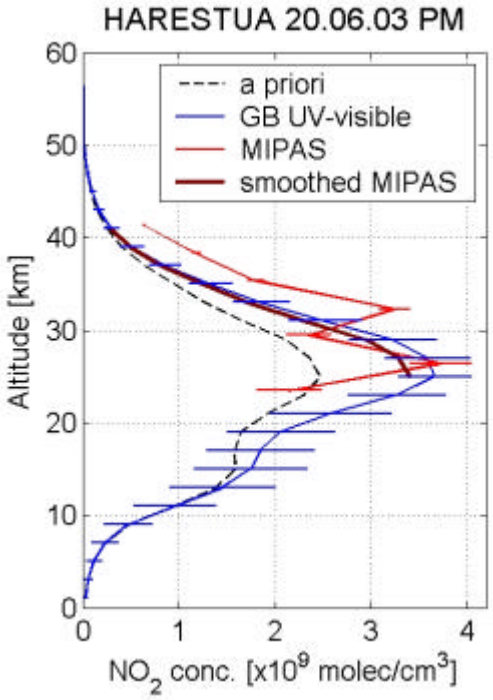
NO_2 (typical) morning result (22-05-2003 am):

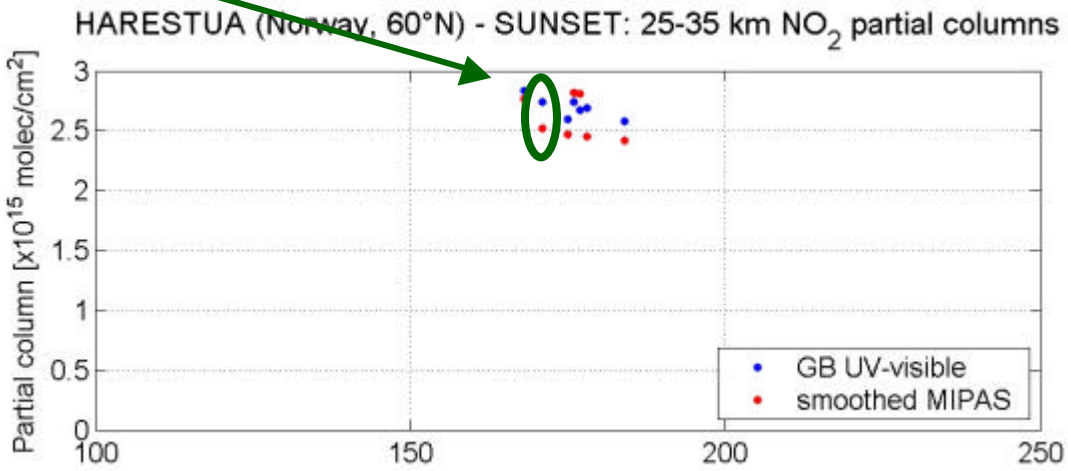


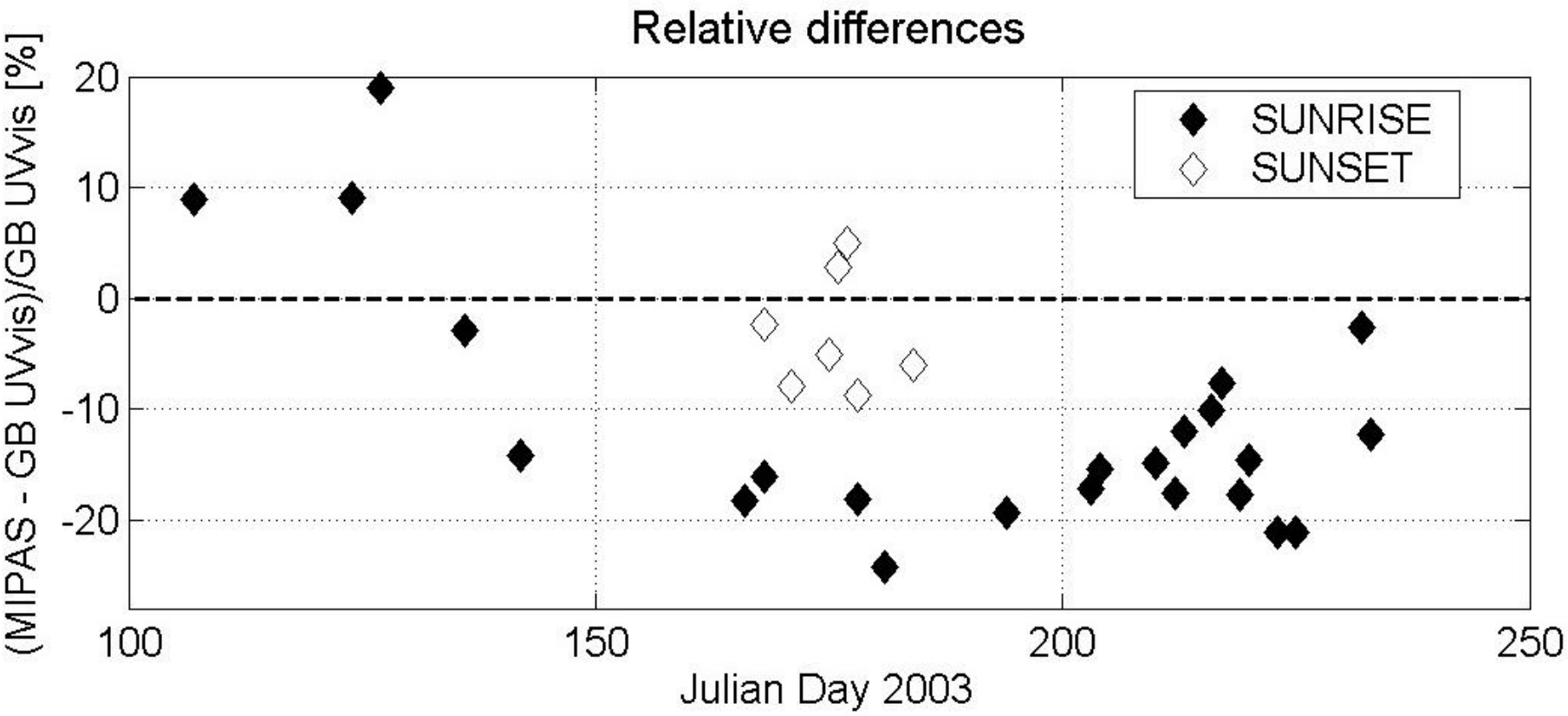



HARESTUA 22.05.03 AM
a priori
GB UV-visible
MIPAS
smoothed MIPAS
Altitude [km]
NO2 conc. [x10^9


HARESTUA (Norway, 60°N) - SUNRISE: 25-35 km NO2 partial columns
GB UV-visible
smoothed MIPAS
Partial column [x10^15 molec/cm^2]


HARESTUA 20.06.03 PM
a priori
GB UV-visible
MIPAS
smoothed MIPAS
Altitude [km]
NO2 conc. [x10^9 molec/cm^3]


HARESTUA (Norway, 60°N) - SUNSET: 25-35 km NO2 partial columns
GB UV-visible
smoothed MIPAS
Partial column [x10^15 molec/cm^2]



- Sunrise (am) behaviour different from sunset (pm) behaviour – due to fact that photochemistry is neglected in MIPAS retrievals ?
- Seasonal variation of relative differences ? At least in am data ?

N_2O, HNO_3 , CH_4 , (O_3)

Only FTIR provide correlative data (except O_3)

solar or lunar absorption measurements

- daytime or nighttime vertical column measurements

- Recently: inversion of low resolution profiles, based on dependence of absorption line shape on pressure (requiring high spectral resolution), using OEM

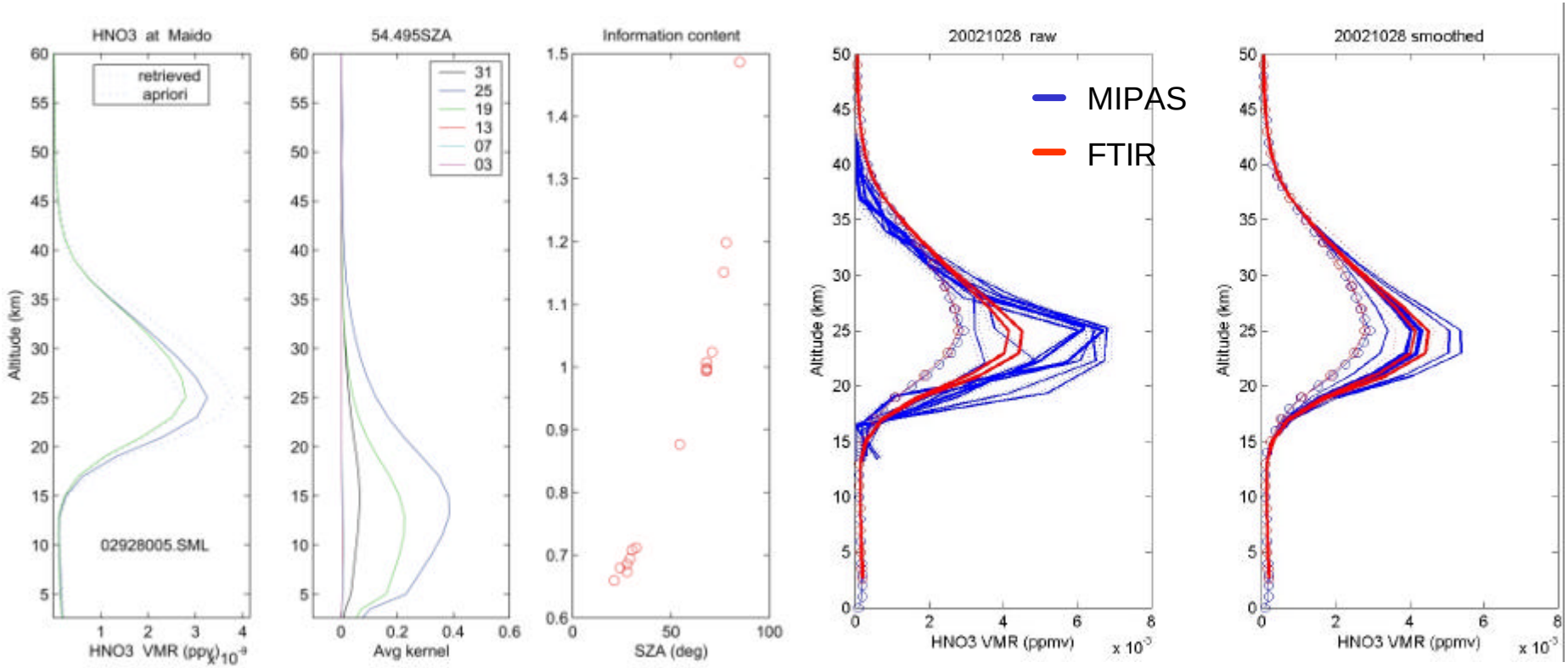
☞ Low vertical resolution intercomparisons, (similar approach as for NO_2)

Results at Reunion Island

- 21°S, 55°E; subtropical complementary NDSC station
- FTIR measurements campaign in Sept-Oct. 2002 as a collaboration between BIRA-IASB, ULB and Univ. Reunion
- FTIR timeseries for Oct. 2002 of many species, incl.
  - N_2O
  - HNO_3
  - O_3
  - ....

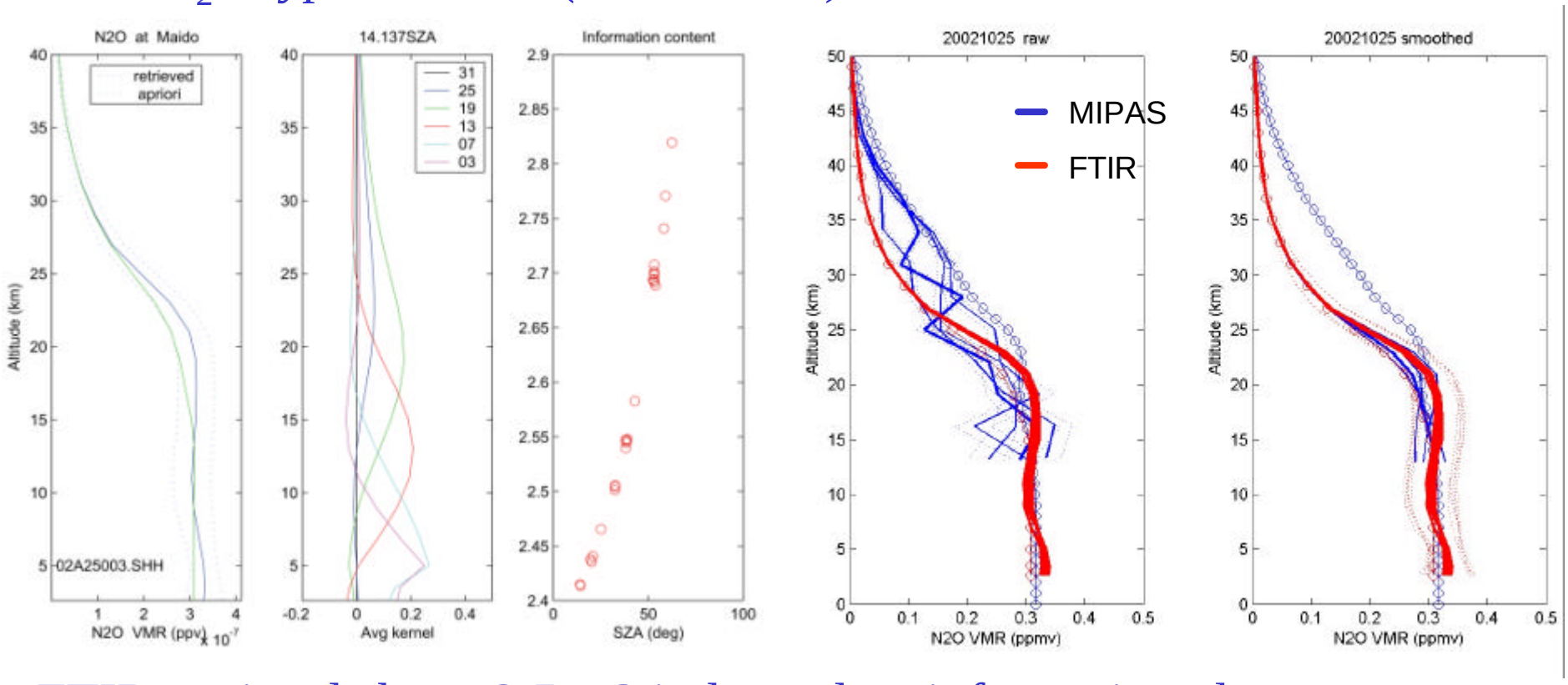
➪Comparisons on 3 days (25, 26, 28 Oct. 2002) with MIPAS v4.53, before pointing (altitude) correction

HNO_3 typical result (28-10-2003)



- A priori far from real profile – still both retrievels agree well
- Essentially FTIR column retrieval !

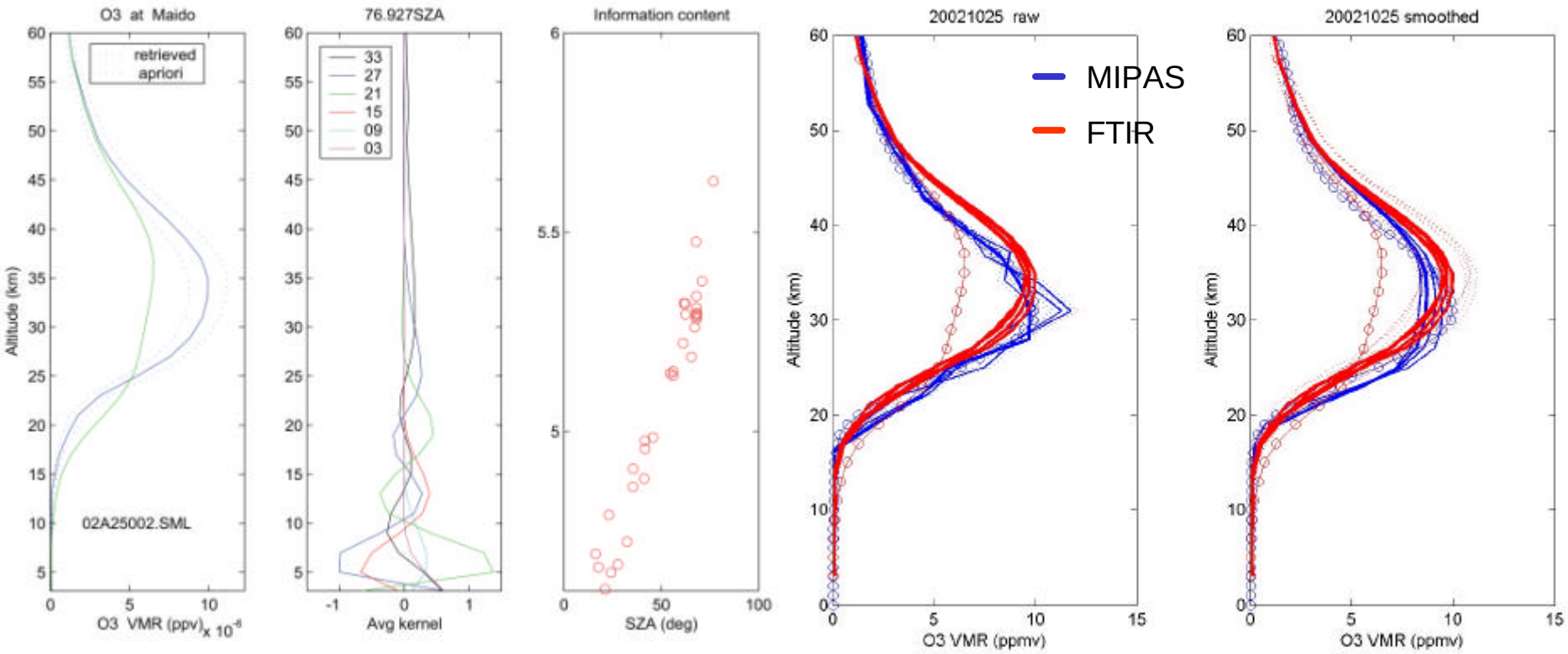
N_2O typical result (25-10-2003)



- FTIR retrievals have 2.5 – 3 independent information elements, situated around 5, 13 and 20 km altitude; almost no sensitivity above 25 km

- Both retrievals confirm maximum of N_2O VMR profile around 22 km altitude in UT/LS where both are sensitive.

O_3 typical result (25-10-2003)



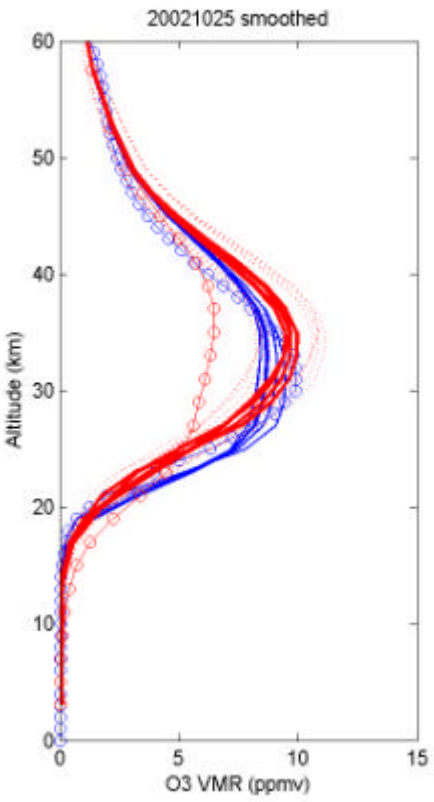
- FTIR retrievals have ~ 5 independent information elements, between 5 and 40 km altitude; vertical resolution ~5 km

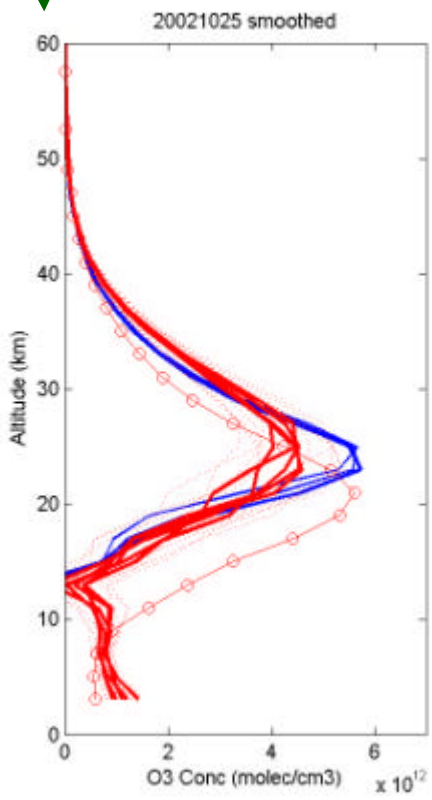
- profile comparisons reflect pointing error of MIPAS before mid november 2002 ?

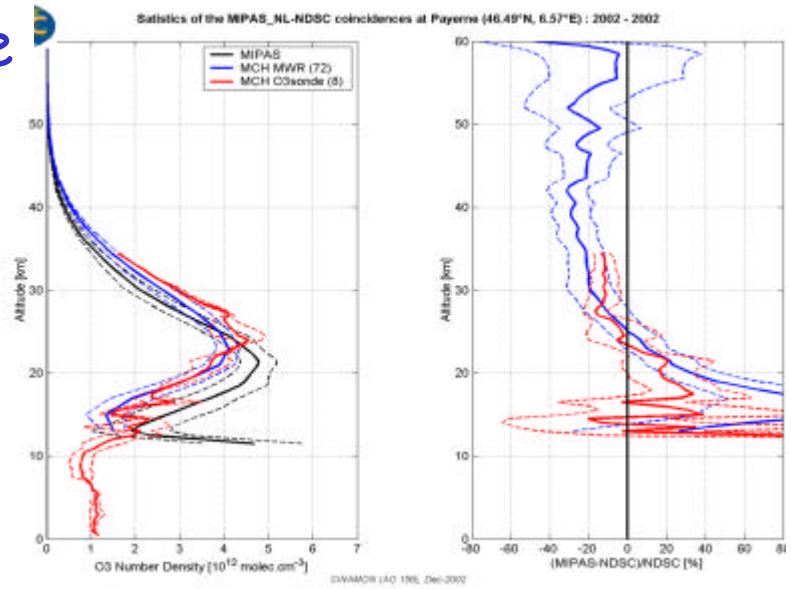
Payerne

Before 20021113

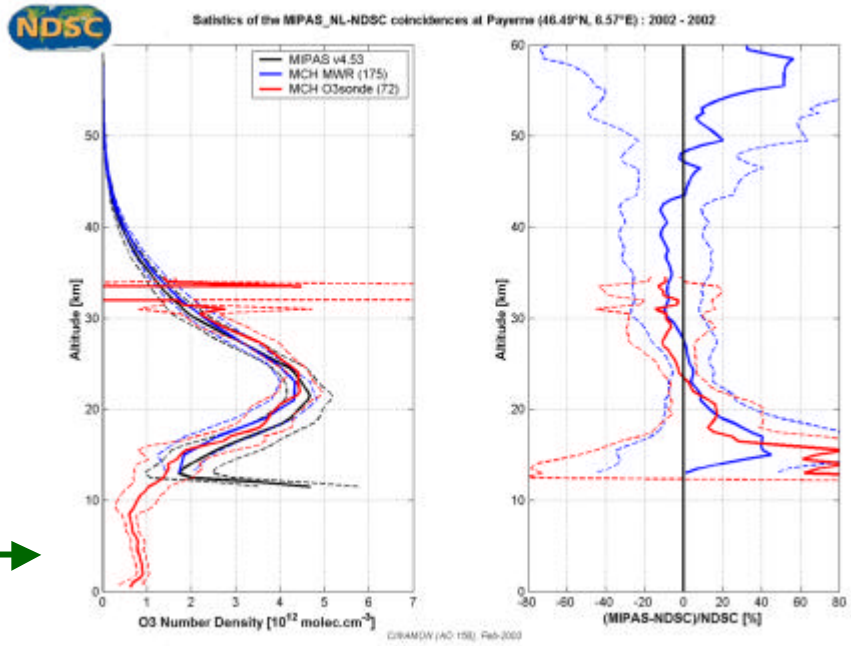
Reunion







After 20021113



Results at other FTIR stations of network ?

Most stations up to now don't provide profile data

- Lauder and Arrival Heights provide distinct strato- and tropo- columns for N_2O and CH_4

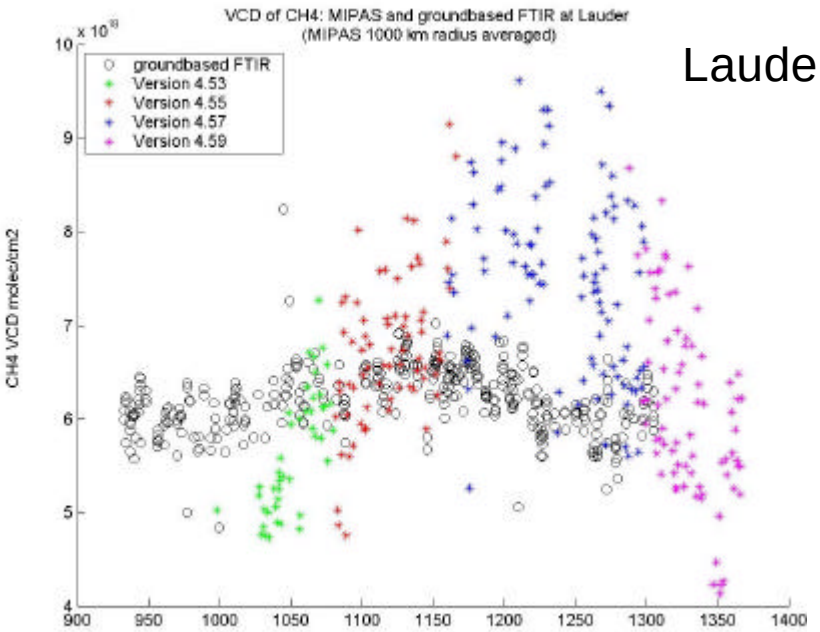
☞ Partial strato- column intercomparisons for N_2O and CH_4

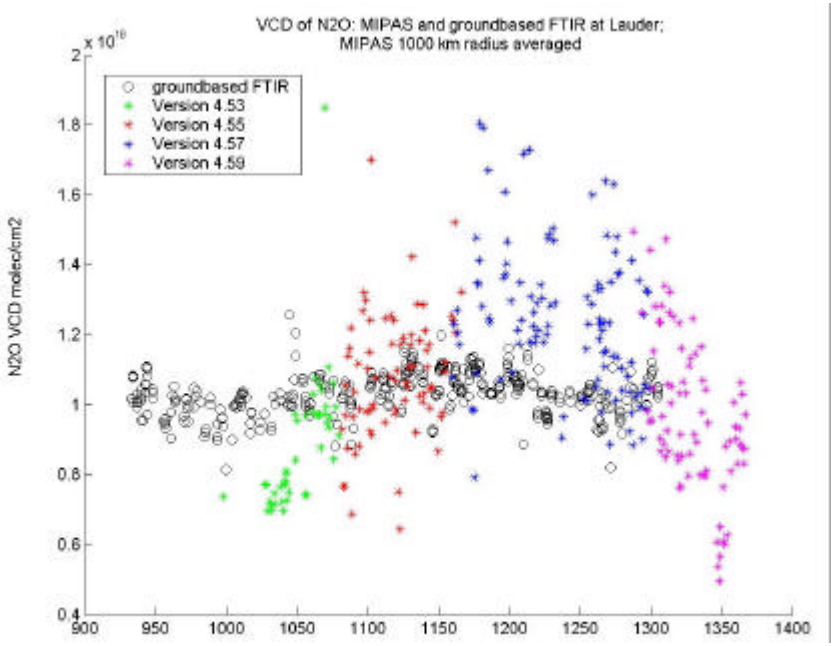
- Other stations provide total column measurements

☞ Total column intercomparisons for HNO_3, assuming tropo- column is negligible

Lauder

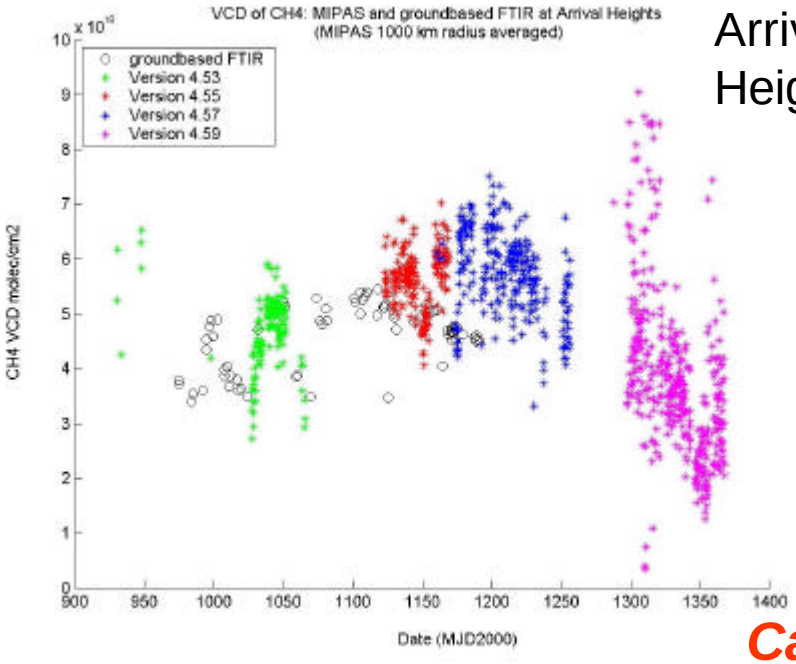
CH4

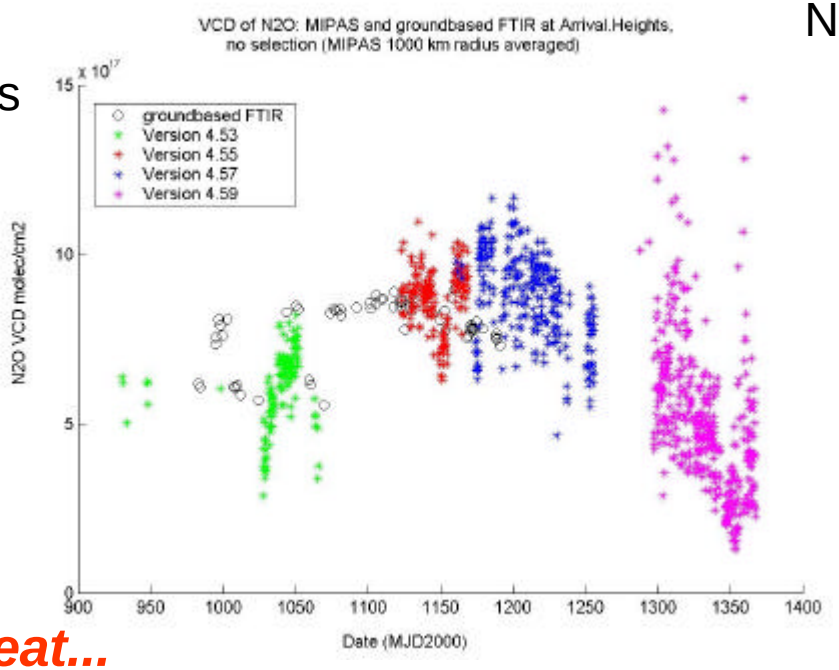




N2O

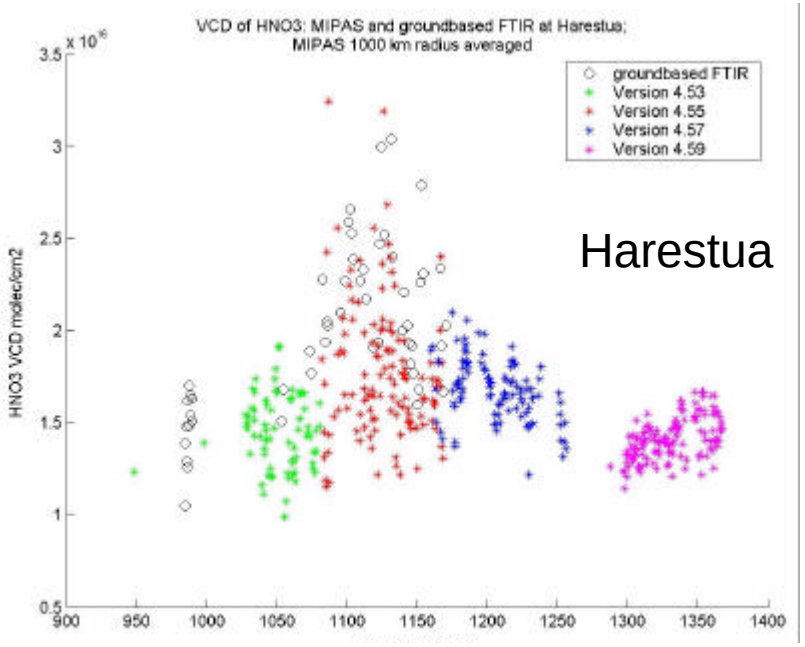
Arrival Heights

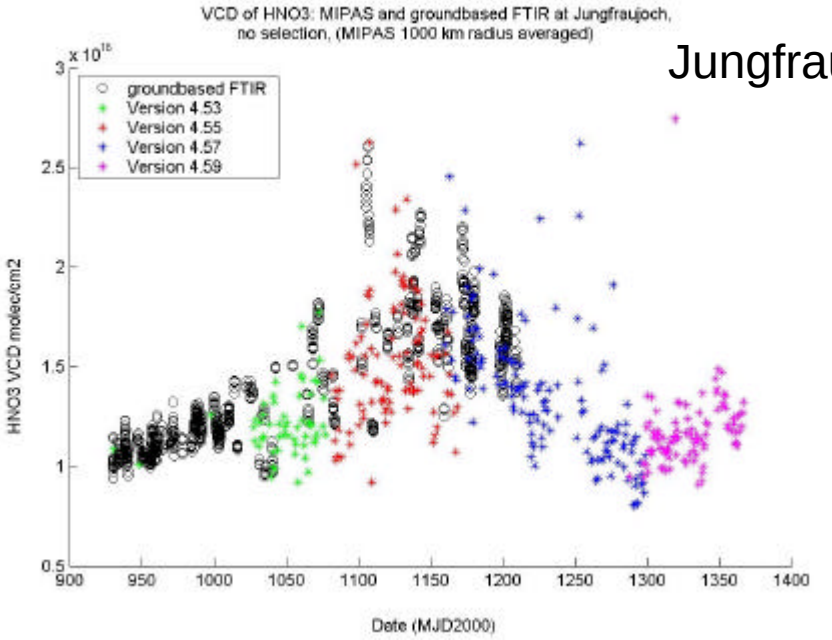


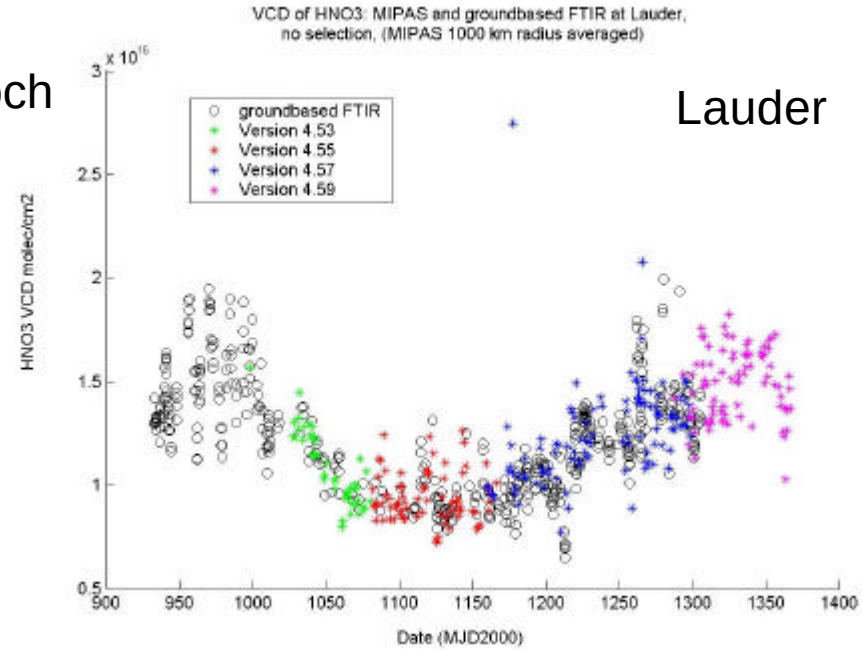


Caveat...

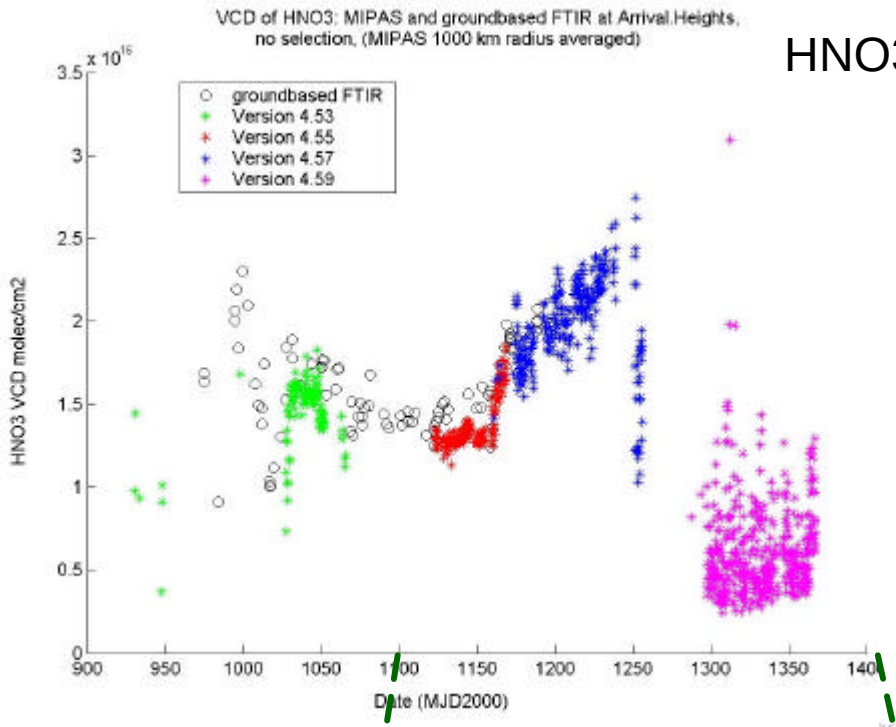
HNO3 total columns





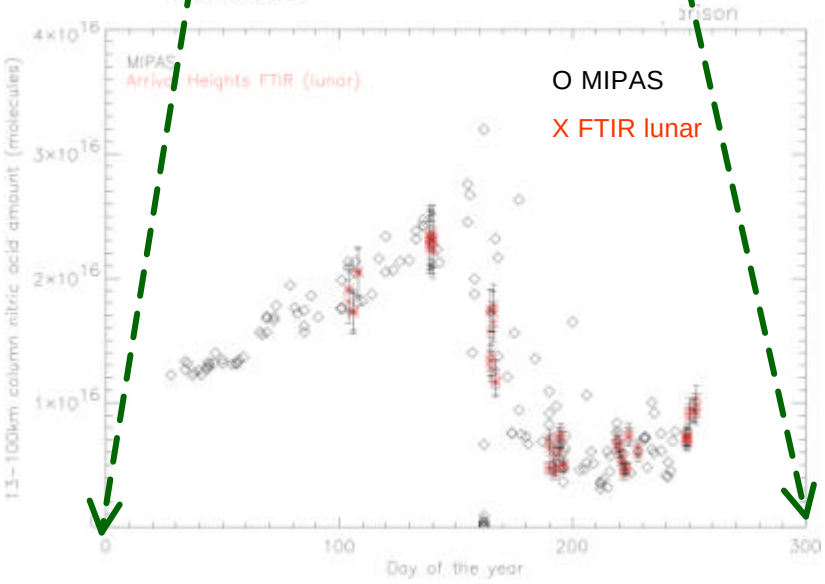


HNO3 total columns at Arrival Heights

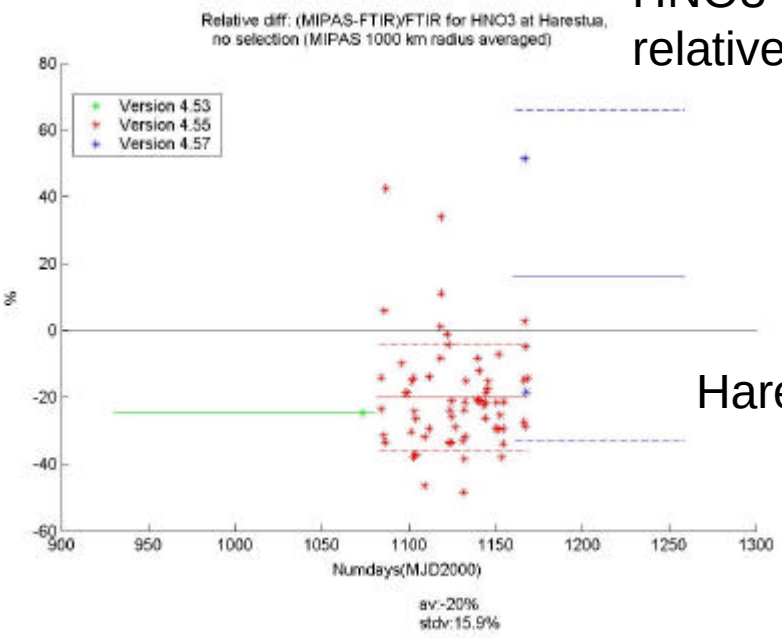


Courtesy:

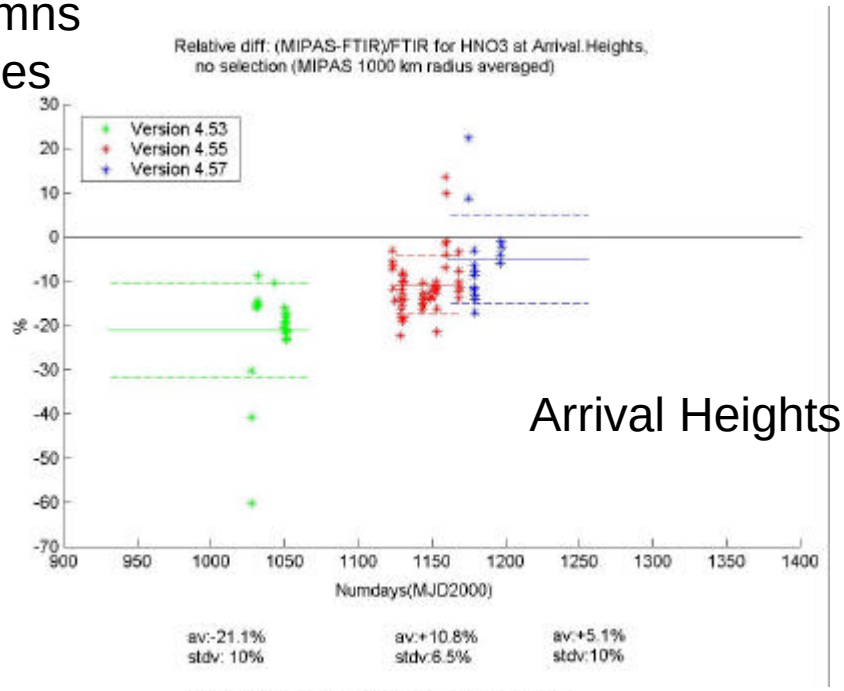
S.Wood & D. Smale - NIWA



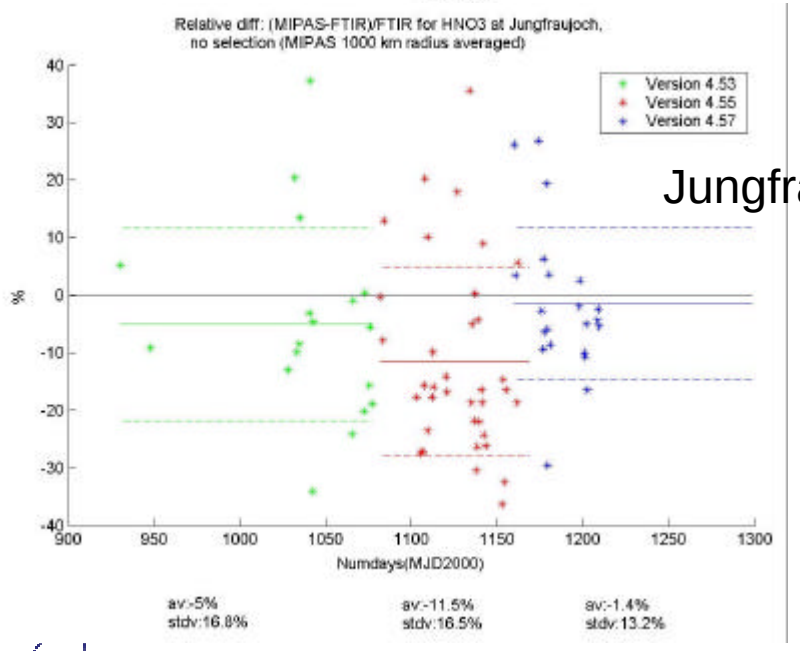
HNO3 total columns relative differences



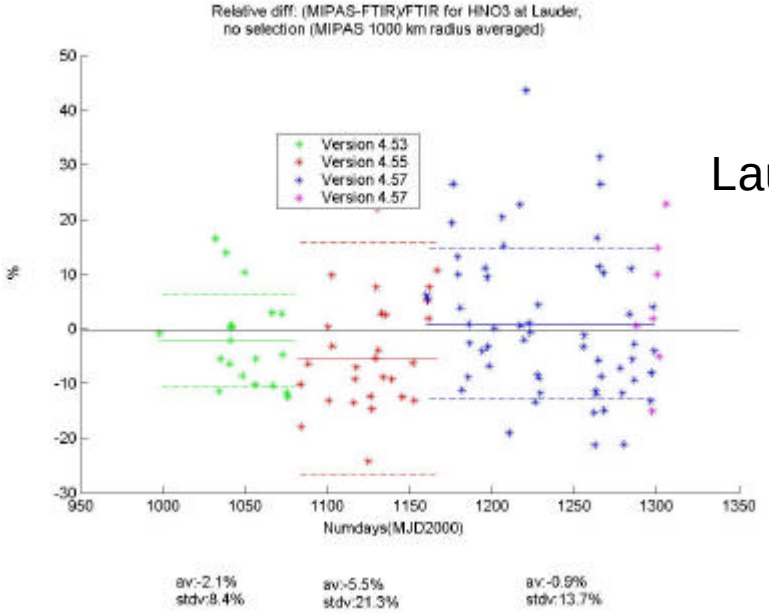
Harestua



Arrival Heights



Jungfraujoch



Lauder

➢ Partial and total column comparisons provide a quick look to the quality of the MIPAS products on a quasi-global scale;

In particular:

detection of changes in the quality of the MIPAS products with successive processor versions.

➢➢ much scatter is observed –

partly due to oscillations in the MIPAS profiles

partly due to too crude co-location criteria

e.g., HNO_3 in winter-spring at close-to-polar locations

Partial column intercomparisons must still be corrected for different column sensitivities

➢➢ has scatter increased in the versions 4.55 and 4.57 ?

Summary & Perspectives

Ground-based network data provide *continuous* **support to satellite data validation, on a** *quasi-global scale*

- **NO_2**

  DOAS profile inversions appear have a significant potential for MIPAS profile validation in the altitude range where the NO_2 concentration peaks

  - ☞ Improve temporal colocation of intercomparisons (model evaluation extended run towards day and night)

  - ☞ Extend to Jungfraujoch – possibly other DOAS stations ?

Summary & Perspectives (cont'd)

- **Other species ...**

  GB FTIR can provide useful profile data for MIPAS validation, in limited altitude ranges; for some species the (partial) column data allow an initial quality check.

  ☞ Extend work done at Reunion Island;
  in particular second campaign in Sept-Nov. 2004 (also for ACE and TES)

  ☞ Extend profile inversion to other stations and additional species in the UT/LS and stratosphere

☞ Improve co-location criteria

☞ Extend to validation of (additional) scientific data products

Acknowledgements

- Technical support for validation activities

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- Network FTIR data and Payerne data

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