SCIAMACHY Ozone Profile Validation

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Acknowledgment: Data from AVDC at NILU were used

Available SCIAMACHY limb ozone profiles

- SCIAMACHY Offline limb ozone profiles (version 2.1)
  - UV wavelengths (to be extended to UV-VIS)
  - 4 ozone profiles per swath, lined up in across-track direction
  - No altitude correction implemented (pointing inaccurate in 2002)
  - Data in altitude or pressure vs. partial columns or mixing ratios

- SCIAMACHY IFE-Bremen limb ozone profiles (version 1.6)
  - Generated from Level 1 data.
  - Chappuis band (VIS)
  - No altitude correction implemented
  - Data in altitude vs. number density

Other SCIAMACHY ozone profiles

- Nadir profiles (Van der A, KNMI; L1 calibration insufficient)
- Differential SCD profiles (Wagner, Univ. Heidelberg; experimental)
- Mesospheric ozone profiles (IFE – Univ. Bremen)
- Solar (50-70°N) & lunar (30-90 °S) occultation (IFE – Univ. Bremen)
  * SCIA on order of 10% (solar) too high compared with SAGE II in 15-35 km region (Amekudze et al., EGU poster)

Limb ozone profile introduction

- Horizontal scans at -5 to +80 km with ~2.5 km intervals
- Scan order reversed for consecutive scans
- Geolocations stored are for individual pixels, in chronological order
- Optimal estimation / Tikhonov algorithms (both include *a priori*)
- Retrievals yield partial column density profiles

Offline product:

- Mixing ratios profiles given derived using AFGL standard atmospheres

  (these are P,T profiles reported)

Comparisons performed with

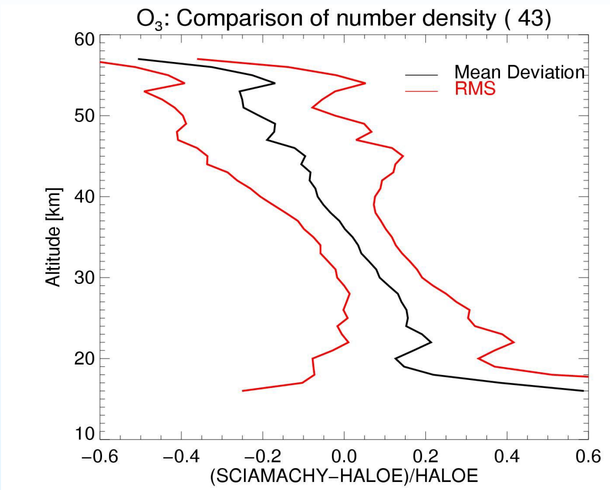
Satellite data:

* HALOE v19, SAGE II, SAGE III, SBUV/2
* no altitude offset correction
* ppmv units as basis

Groundbased data:

* lidar, microwave, FTIR, balloon sondes (~15 sites)
* altitude offset varied, optimized per location
* number density units (from ppmv and/or partial columns), often also ppmv

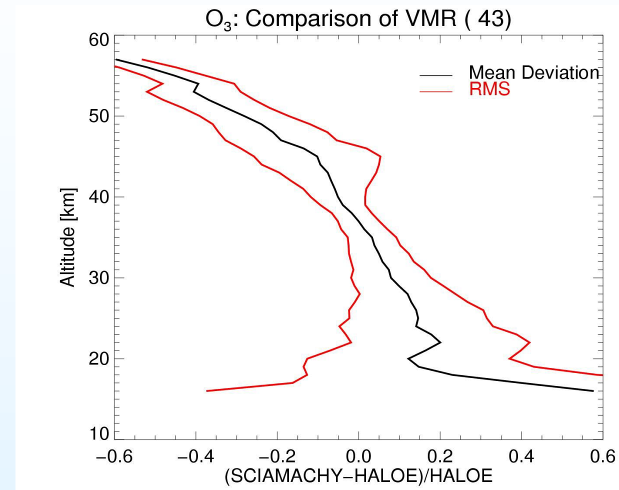
SCIAMACHY OFFLINE v2.1 DATA

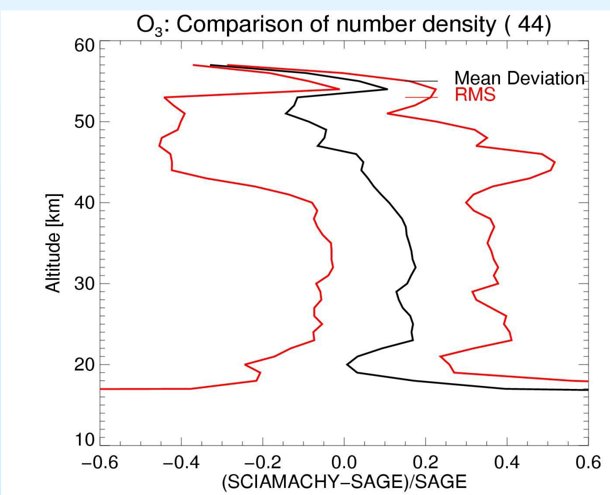


HALOE (v19)

in number densities:
at 21 – 43 km:
[-8, 20%] (+/- 20%)

in VMR:
at 22 – 43 km:
[-6,+20]% (+/- 20%)

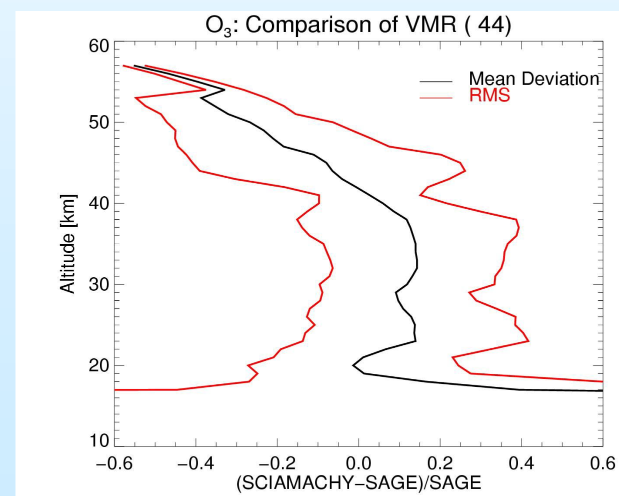




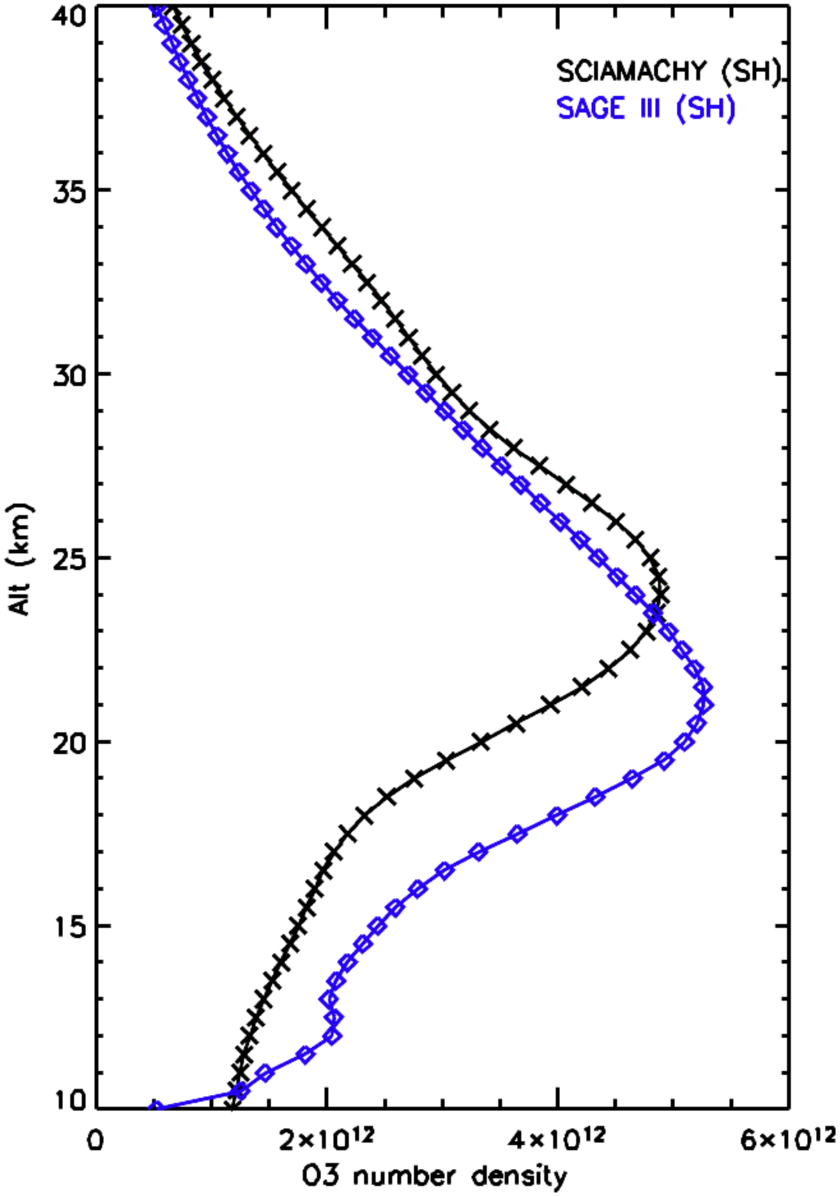
SAGE II (6.2)

in number densities:
at 21 – 41 km:
[3, +17%] (20–25%)

in VMR:
at 22 – 41 km:
[0, +15%] (20–25%)



Bias between HALOE and SAGE II



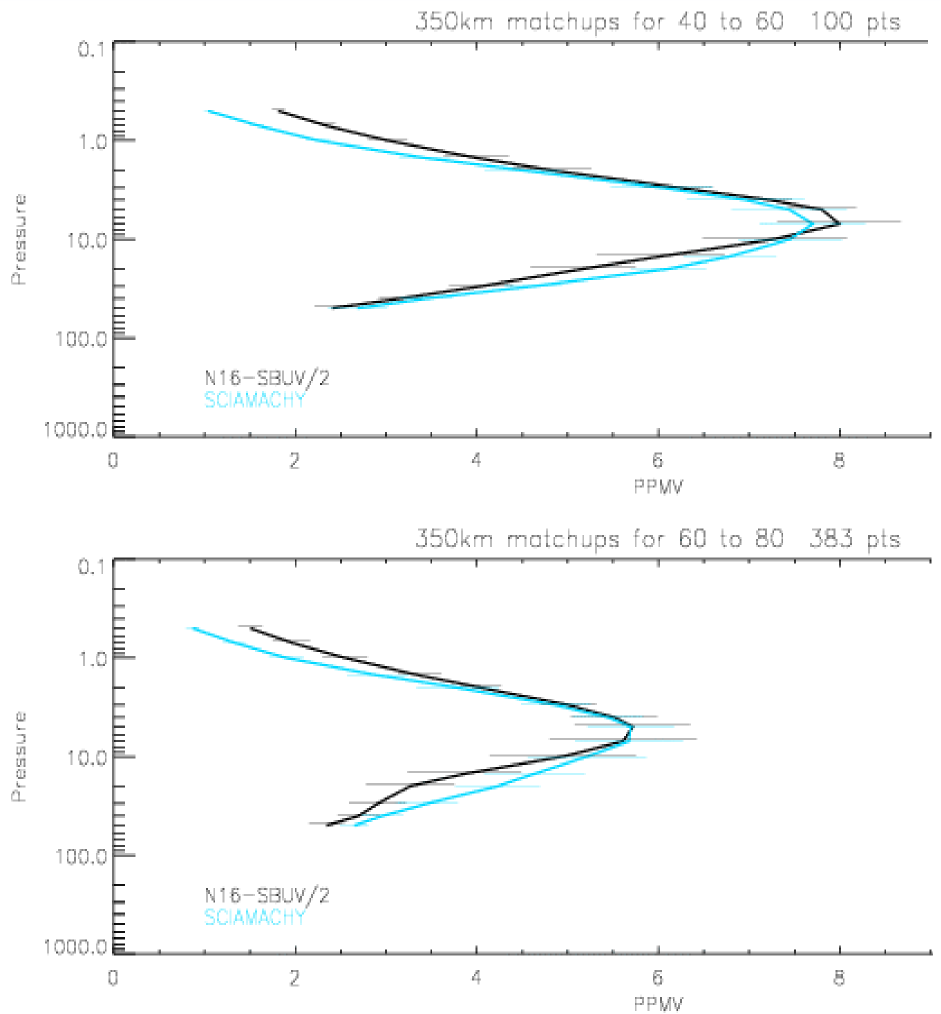
ENVISAT
CARING FOR THE EARTH

Results: SAGE III (Taha et al.)

Lat band	mean diff [%]	number
NH	[-30,25]	201
SH	[-40,25]	453

Numbers for 15-45 km range, alt. not corrected

Note: Altitude shift apparent below 23 km (NH) or throughout profile (SH)



SBUV/2 (Hilsenrath et al.)

Lat band	%diff*	number
-80 to -60	[-45, 17]	61
-60 to -40	[-45, 20]	21
-40 to -20	[-40, 17]	12
-20 to -00	[-40, 15]	5
00 to 20	[-40, 40]	11
20 to 40	[-45, 30]	12
40 to 60	[-45, 18]	100
60 to 80	[-45, 30]	383

* (SCIA-SBUV)*100%/SBUV @ .5 – 50 hPa

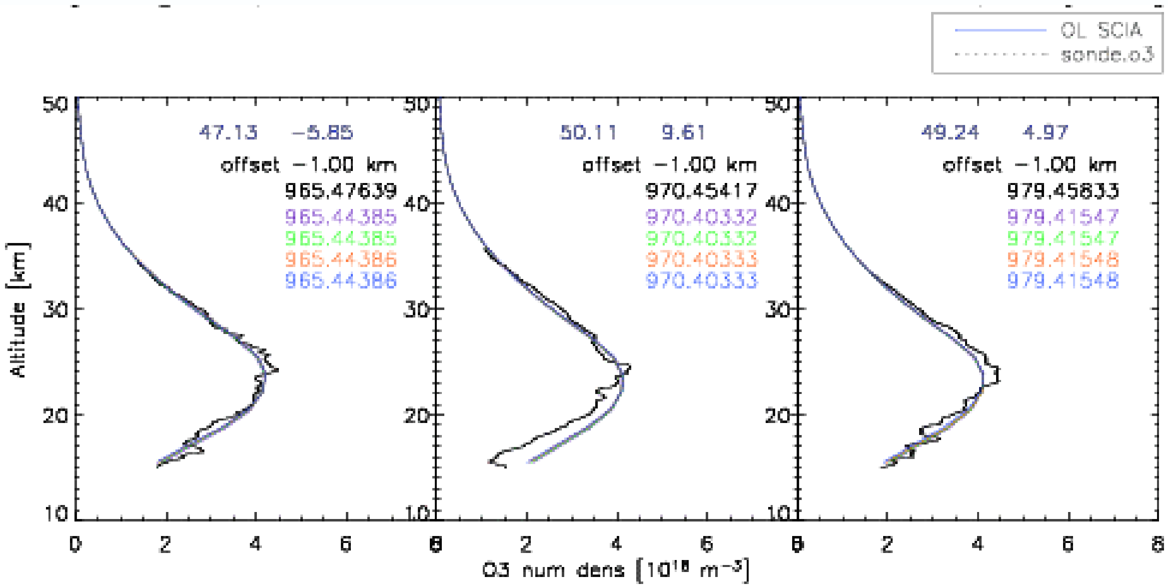
Altitude shift ?

Typically: SCIA O3 too high in lower stratosphere (under ~50 hPa level), too low in higher stratosphere.

SH average: [-45,18]%

NH average: [-45,28]%

SCIA OL V2.1 with lidar & sondes

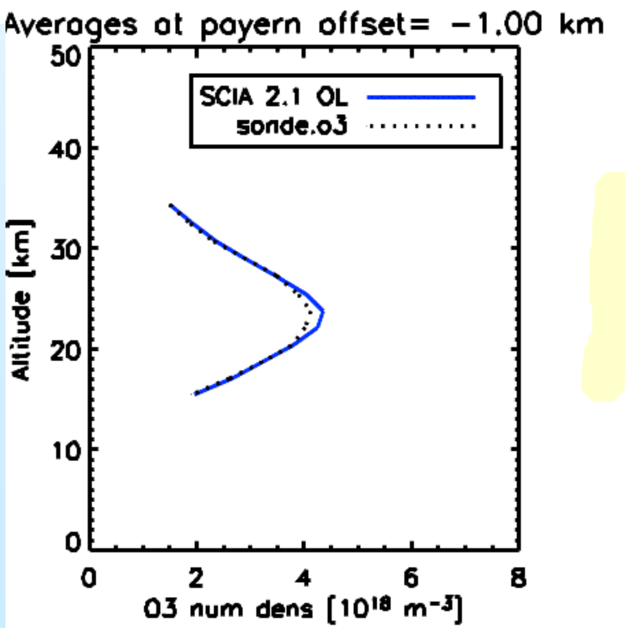


Examples (Payern):

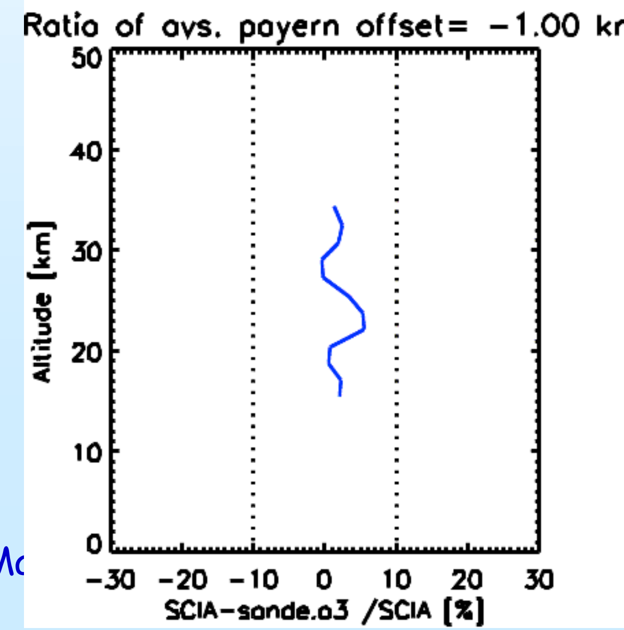
Sondes collocated with

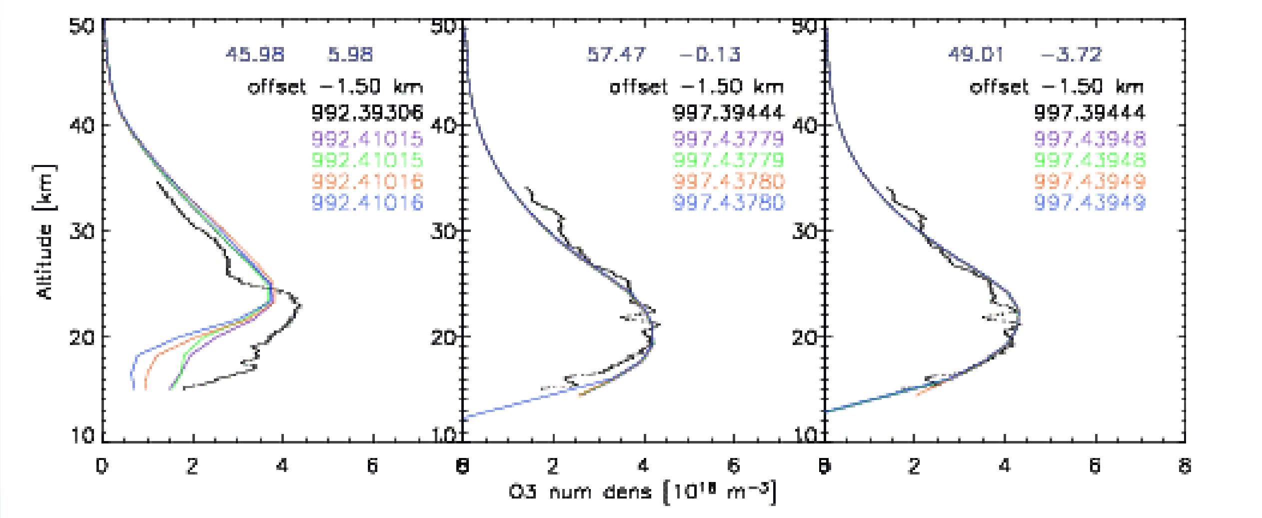
4 SCIA profiles per state

(here – almost identical)



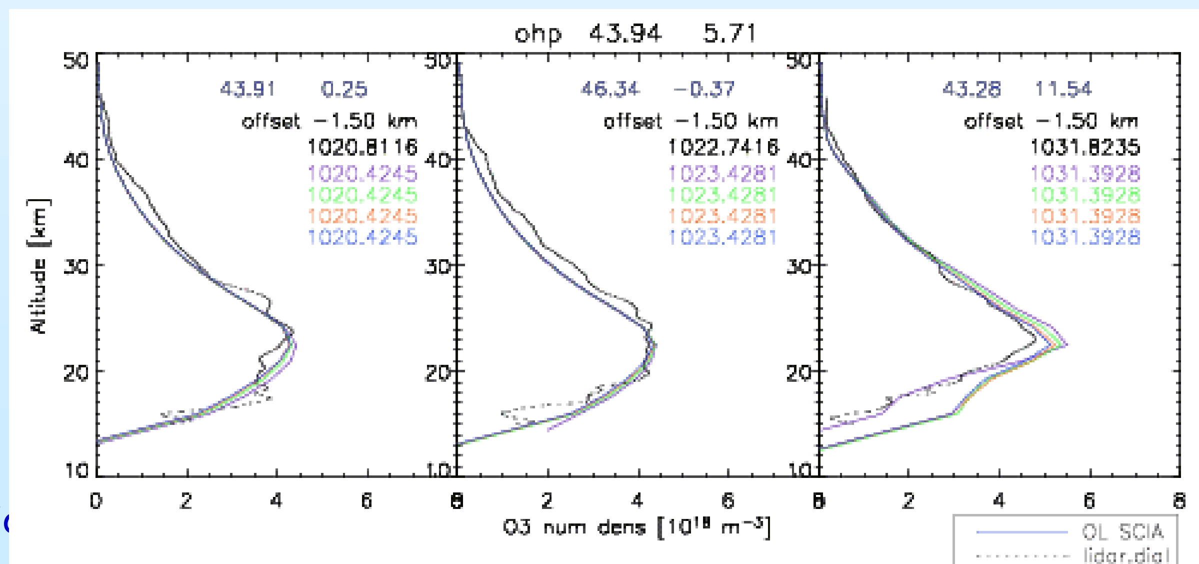
Averages of 30 sondes, collocated with 4 x 30 SCIA profiles at Payern





De Bilt

Haute Provence



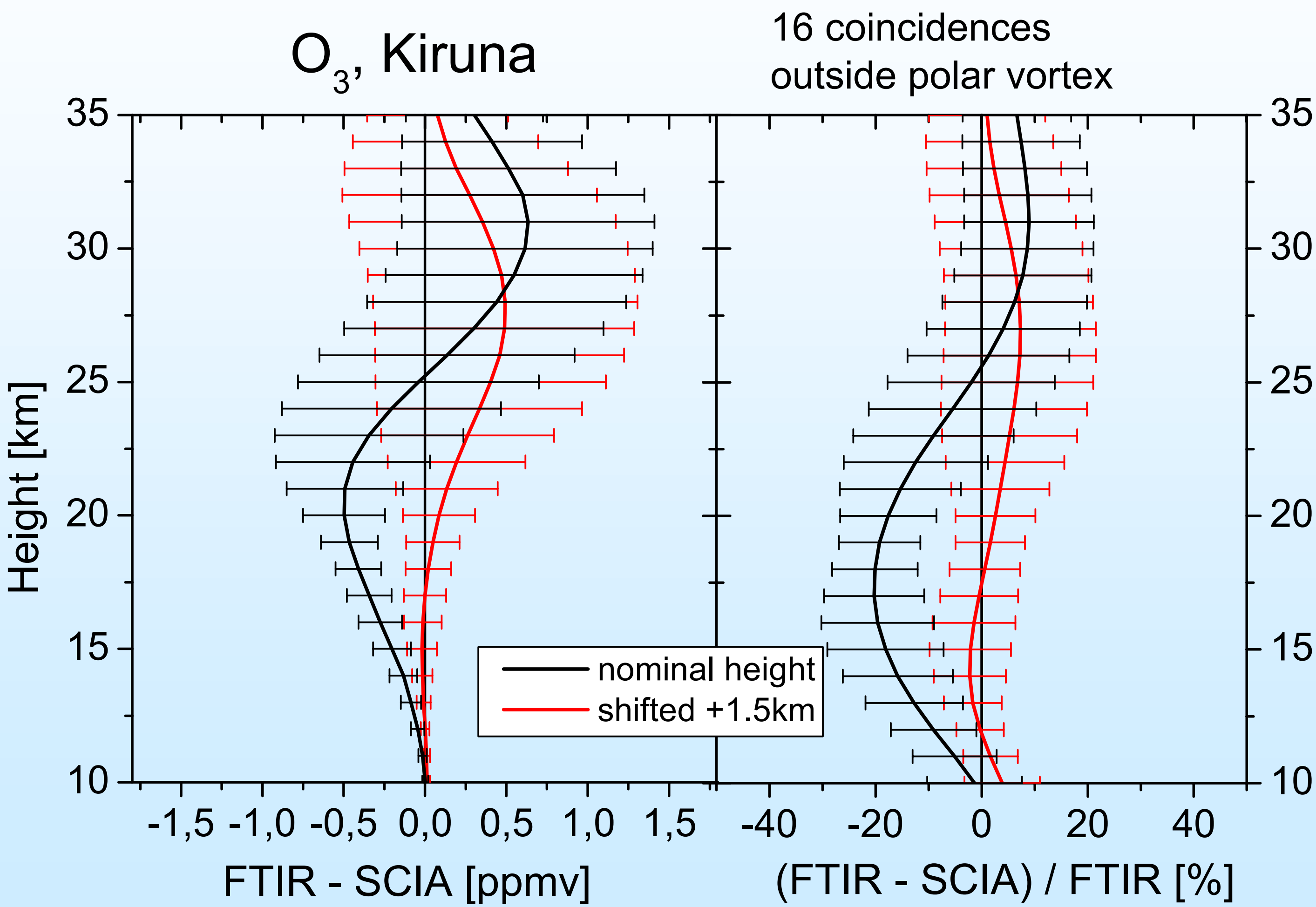
SCIA Offline V2.1 compared with lidar & sondes

Location	instrument	% diff*	number	alt offset [km]	
Uccle	sondes	[-12, +15]	31	-1.5	NH
De Bilt	sondes	[- 8, + 7]	14	-1.5	NH
Hohenpeissenberg	lidar&sondes	[- 8, +12]	24/21	-1.5	NH
Payern	sondes	[- 1, + 6]	30	-1.0	NH
Table Mountain	lidar	[- 7, +10]	5	0	
Mauna Loa	lidar	[- 7, +12]	3	-1.5	tropics
Lauder	lidar	[-11, +10]	21	-1.0	SH
,,	sondes	[-12, +20]	11	-1.0	SH

* (SCIA-x)*100%/SCIA @ 20-40 km (lidar) or 15 km – burst (~35 km, sondes)

Collocation criterion: within 18 hours and 1000 km (from limb state corners)

SCIAMACHY OL v2.1 with FTIR (Blumenstock et al.)



UV-sensitivity below 20 km expected to be very low!

Note: sign reversed!

Multiple Instrument Comparison (Boyd et al.)

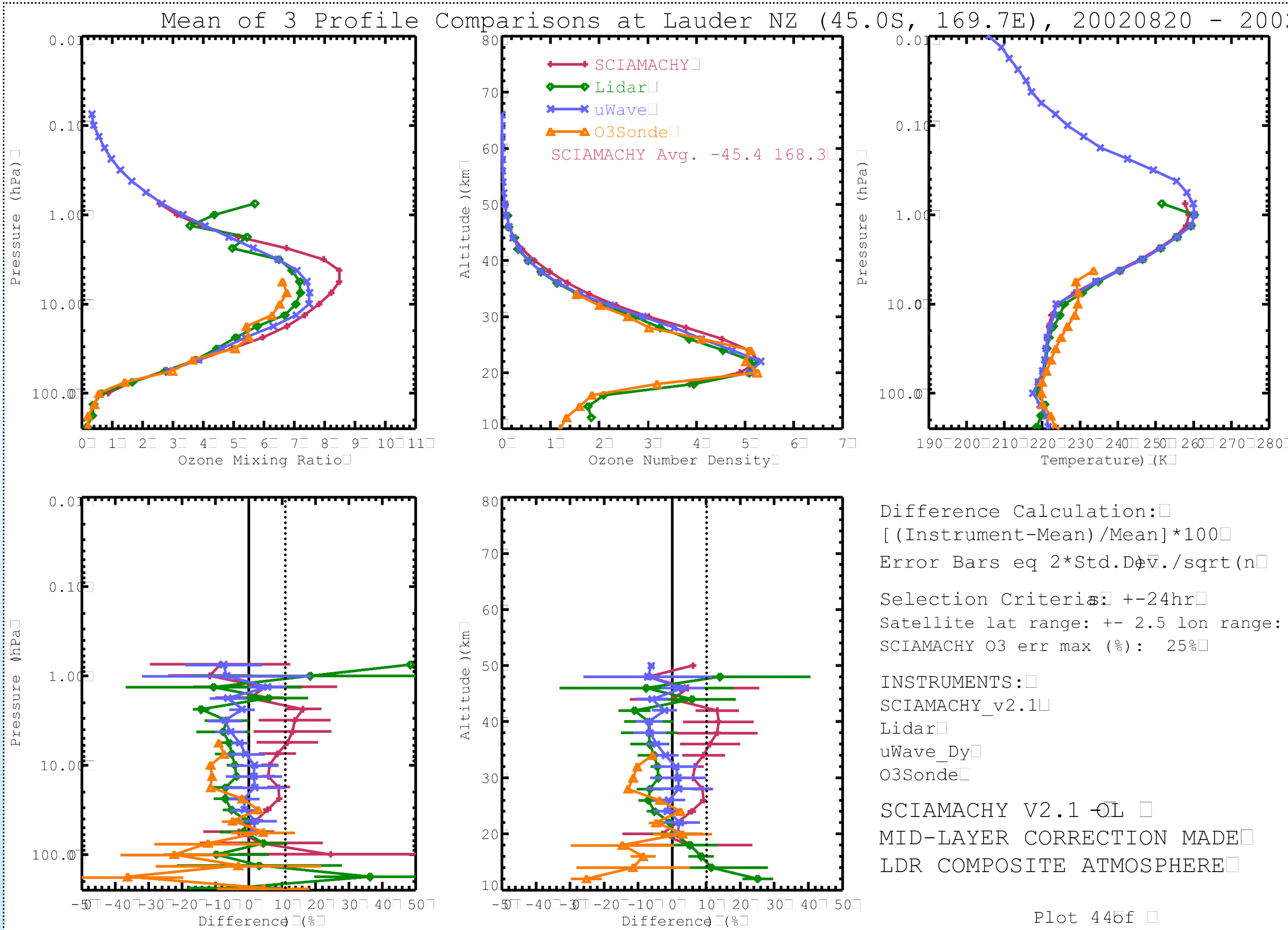
Same-SCIA-profile collocations with:

- microwave, lidar, sondes at Lauder, New Zealand (45°S)
- microwave and lidar at Mauna Loa, Hawaii (20°N)

Composite atmospheric profiles (up-to-date analyses) used for unit conversions (mixing ratio to number density profiles)

Mid layer correction implemented (profiles reported are shifted upward by 0.5 Δz, or equivalent in pressure, alt/pres scale interpreted as *lower and upper boundaries*)

Difference plots (%) are relative to average of all instruments



Mean of 3 Profile Comparisons at Lauder NZ (45.0S, 169.7E), 20020820 - 200
SCIAMACHY
Lidar
uWave
O3Sonde
SCIAMACHY Avg. -45.4 168.3
Pressure (hPa)
Altitude (km)
Ozone Mixing Ratio
Ozone Number Density
Temperature (K)
Difference (%)
Difference Calculation:
[(Instrument-Mean)/Mean]*100
Error Bars eq 2*Std.Dev./sqrt(n)
Selection Criteria: +-24hr
Satellite lat range: +- 2.5 lon range:
SCIAMACHY O3 err max (%): 25%
INSTRUMENTS:
SCIAMACHY_v2.1
Lidar
uWave_Dy
O3Sonde
SCIAMACHY V2.1 -OL
MID-LAYER CORRECTION MADE
LDR COMPOSITE ATMOSPHERE
Plot 4 of

Conclusions Lauder & Mauna Loa (number density profiles)

Lauder (45°S)	Offline v2.1 [11 pairs]		IFE v1.6 [12 pairs]	
lidar & mwave:	-4% (4%)	17-25 km	-4% (3%)	15-40 km
	+5% (4%)	25-45 km		

Conclusions: Offline V2.1 SCIA biased low <25 km, high 25-45 km,

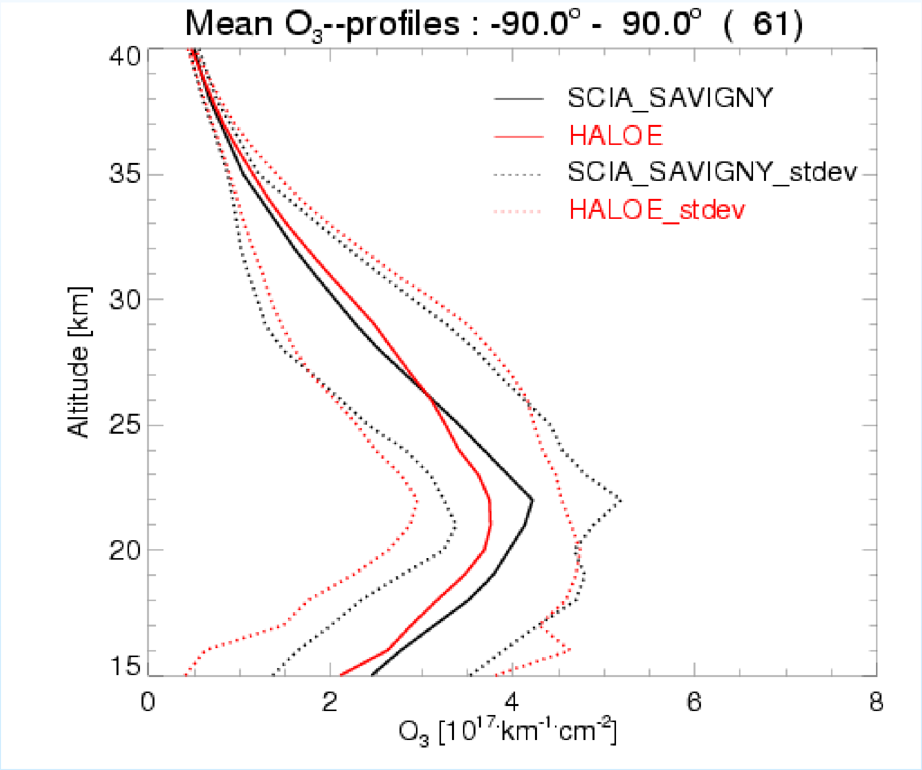
IFE V1.6 SCIA biased low 15-40 km, high 40-70 km.

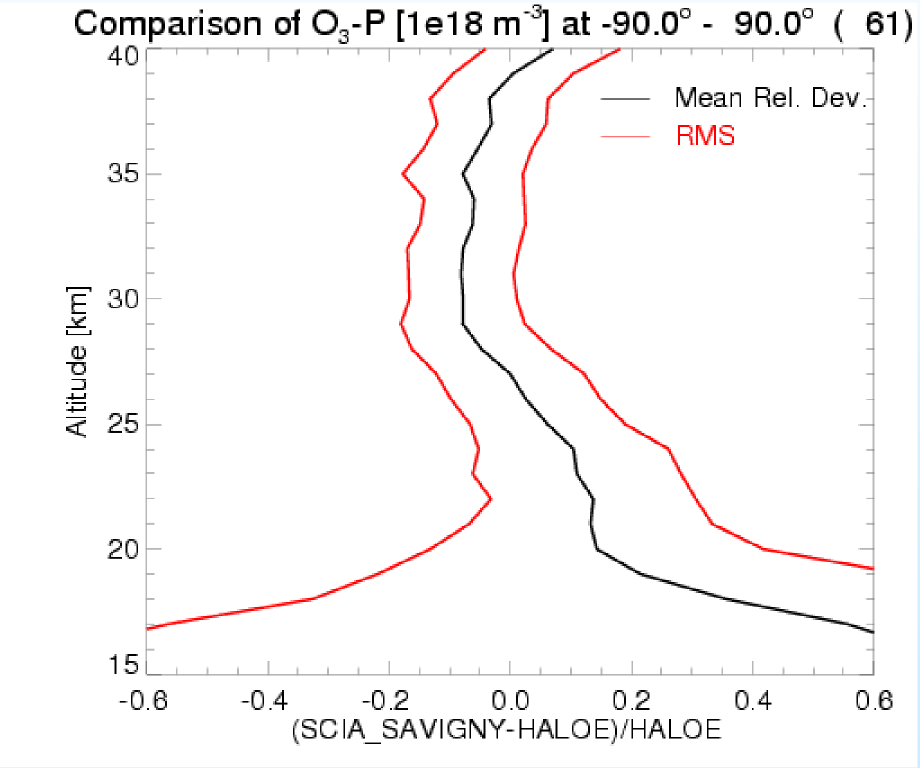
Offset –1.5 km applied to both data sets.

Mauna Loa (20 °N)	Offline v2.1 [4 pairs]	IFE v1.6 [21 pairs]	
lidar & mwave:	0% (1%) 18-25 km	-3%(2%)	20-30 km
	2% (4%) 25-45 km	+3%(2%)	30-40 km

SCIAMACHY IFE-Bremen V1.6 DATA

IFE v 1.6 versus HALOE (A. Bracher et al.)





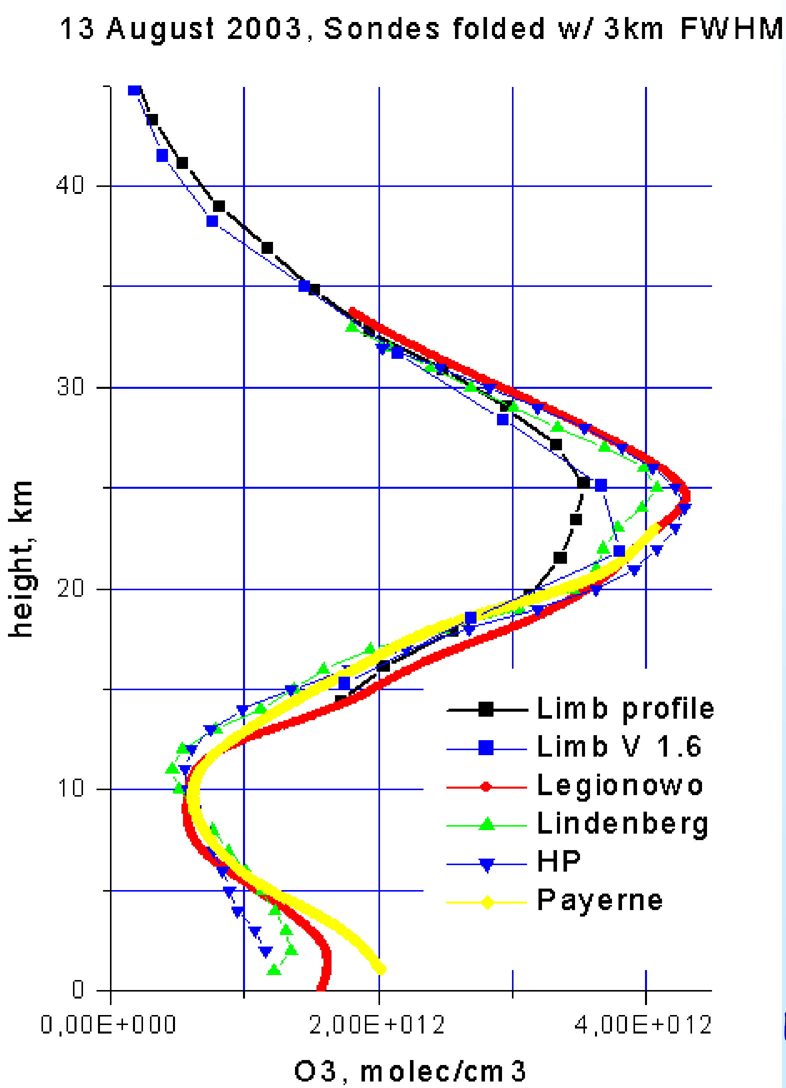
IFE v1.6 compared with lidar & sondes

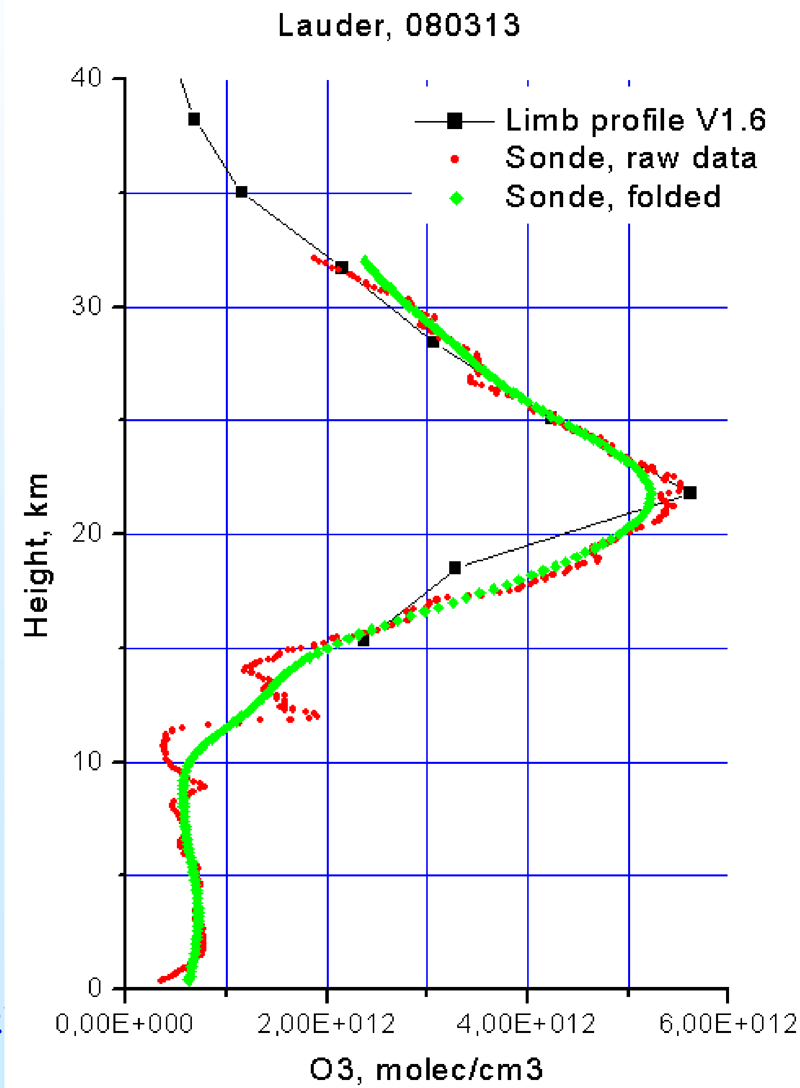
Location	instrument	% diff*	alt offset [km]	
Alomar, Ny Alesund	lidar	[-20, +15]	-3.0	NH
Uccle	sondes	[-10, +40]	-1.5	
De Bilt	sondes	[- 8, + 7]	-1.5	
Hohenpeissenberg	lidar&sondes	[- 15, +20]	-1.5	
Payern	sondes	[-20, +40]	-1.0	
Table Mountain	lidar	[- 7, +10]	0	
Mauna Loa	lidar	[- 7, +12]	-1.5	tropics
Paramaribo	lidar	[-20, +60]	-1.5	
Lauder	lidar	[-25, + 0]	-1.0	SH
,,	sondes	[-20, +30]	-1.0	

* (SCIA-x)*100%/SCIA @ 10-35 km range

Collocation criterion: within 18 hours and 1000 km

IFE v1.6 compared with sondes (A.-M. Schmoltner et al.)





Summary offline ozone profile results

	HALOE	SAGE II
21-43 km num.density	[-8, 20]	[-3, 17]
22-43 km mixing ratio	[-6, 20]	[0, 15]
	SBUV/2	SAGE III
NH	[-45,28]	[-30, 25]
SH	[-45,18]	[-40, 25]

From sat-SCIA validation: SCIA biased high in low strat, biased low in high strat

	lidar or sonde	simultaneous lidar & mwave (17-25 km)	(25-45 km)
NH (5 loc)	[-7,10]		
Mauna Loa (4 collocations)	[-7,12]	[-1, 1]	[-2,6]
SH (Lauder)	[-11,15]	[-8,0]	[1, 9]

From groundbased-SCIA validation: Less consistent picture

All numbers: range of average (SCIA – X) in percent

Summary IFE-Bremen v1.6 ozone profile results

Sat-sat comparisons	HALOE
21-43 km num. density:	[-7, 15]

IFE – HALOE: comparable result with SCIA OL - HALOE

SCIA-groundbased/sondes	lidar or sonde
NH (7 locations)	[-14,21]
(sub)tropics (2 locations)	[-13,36]
Lauder	[-22,15]

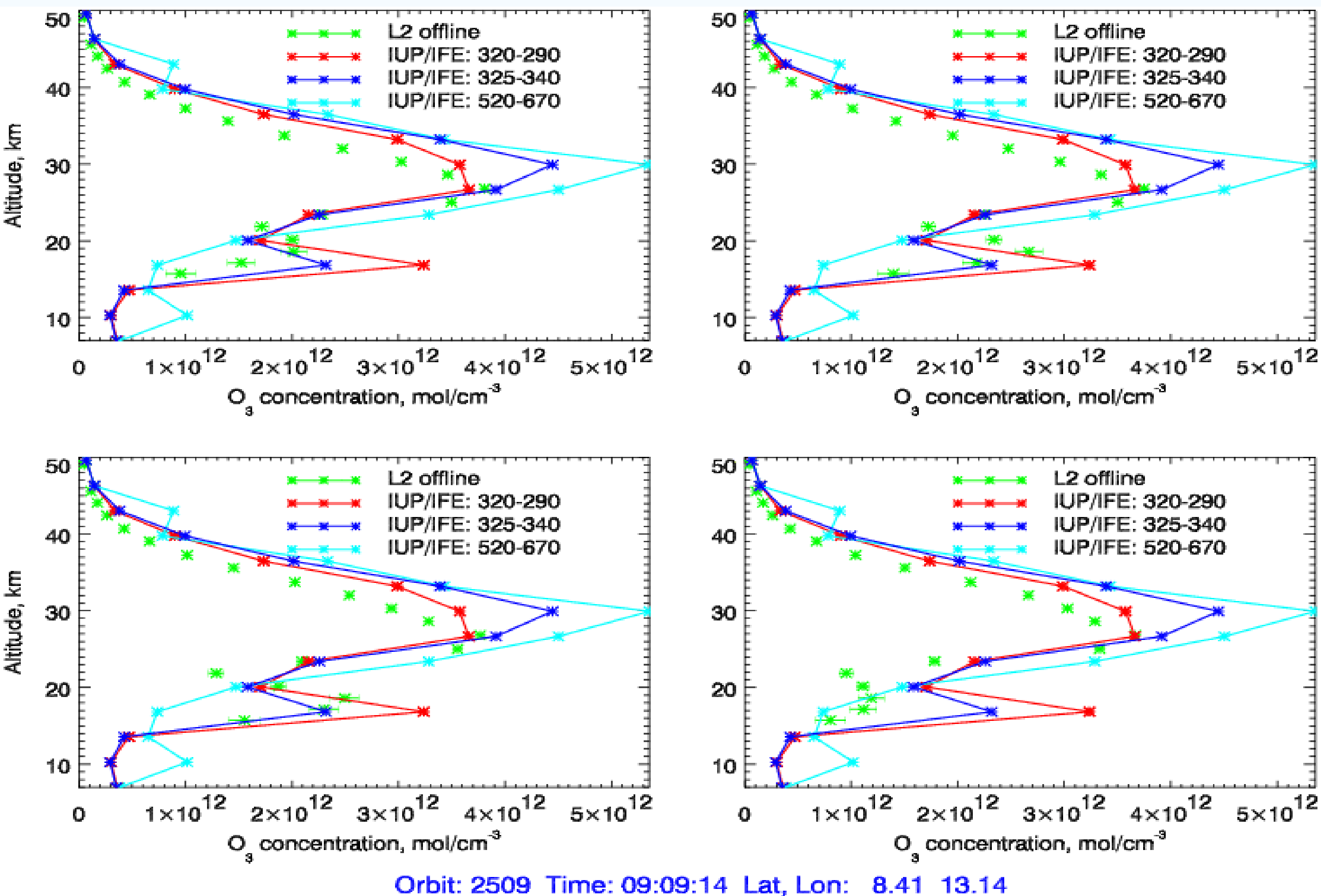
IFE – groundbased: range about 2x larger than SCIA OL - groundbased

All numbers: range of average (SCIA – X) in percent

Ozone: spectral windows

Indicates fit window should shift (currently only UV)

From: A. Rozanov et al., Verification of O3 and NO2 vertical profiles from L2 offline product



To do list

- Decide on altitude shift (Envisat pointing problem) corrections in 2002 validation results
- Take into account a priori / averaging kernels
- Separate cloud-free/clouded scenes
- Other dependencies (total ozone, viewing angle, etc.)
- Check errors introduced in unit conversions (e.g., P,T profiles used)
- Validate again after OL processor update (including VIS wavelengths)
- Use more groundbased data (and longer SCIA dataset when available)

Will lead to more uniform validation results and firmer conclusions

Notes on conclusions O3 profiles

- Different subsetting (e.g., Lauder and Mauna Loa) influences results, partially because of low-number statistics (3-30 collocations).

- Offline as well as IFE – consistent conclusions per site usually difficult (i.e. standard deviation in bias is high)

- All conclusions are very preliminary, validation is ongoing:

1) More consistent approach between validation efforts needed
2) Altitude corrections needed (location and time dependent). These also influence mixing ratio results, since P-profiles are used in unit conversions).

More notes on conclusions O3 profiles

- IFE data: larger set than SCIAMACHY OL profiles, will be better for investigating altitude offset and other dependencies.

- IFE algorithm has proven useful for OL algorithm updates (e.g., planned extension of fit window wavelength range)

Backup Material

Recommendations to algorithm developers (open for discussion)

- Change altitude and pressure grids by "half a bin" so users can plot profiles as they are (also provide average number densities rather than partial column densities)
- Use/provide accurate P,T profiles (now: standard atmosphere)
- Implement correction for pointing inaccuracy
- ...