SCIAMACHY Validation with Solar FTIR Spectrometry at the NDSC Primary Station Zugspitze

DLR Contract: 50 EE 0007

Principle Investigator:
Ralf Sussmann, IMK-IFU, Garmisch-Partenkirchen, FZK

Alexander Rockmann (engineer)
Markus Rettinger (engineer)
Wolfgang Stremme (PhD Student)

Acknowledgment:
Michael Buchwitz (Uni Bremen)
Rüdiger de Beek (Uni Bremen)
Andreas Richter (Uni Bremen)

Zugspitze Solar FTIR: NDSC Primary-Status Instrument

0.00186 cm^{-1} resolution
(OPD = 486 cm) Bruker
IFS120HR FT-spectrometer

- SFIT1.09e/2.38
- FASCATM 2.03 raytracing

SCIAMACHY Validation by FTIR at Zugspitze: Schedule, Activity

Species: CO, CH_4, N_2O, O_3, NO_2

Contract-Committment:

Commissioning Phase: Intense measurement phase between L+3 and L+6; measurement intensity: **two weeks per month**; columns be made available within 45 days.

Main validation phase: Intense measurement phase between L + 6 and L + 18 months; measurement intensity: **one week per month**; columns will be made available within 90 days.

Long-term validation phase: L+18 – project end: Routine operation (once a week).

We did much more: permanent 4 weeks per month operation on all clear sky days

„5.5 months Commissioning Phase“: including weekends

15 July - 31 Dec 2002: ***60 Measurement days at Zugspitze within first 5.5 months.***

Main validation phase:

15 July 2002 – 1 July 2003: ***127 measurement days within first 11.5 months.***

All retrievals have been submitted to Cal/Val database

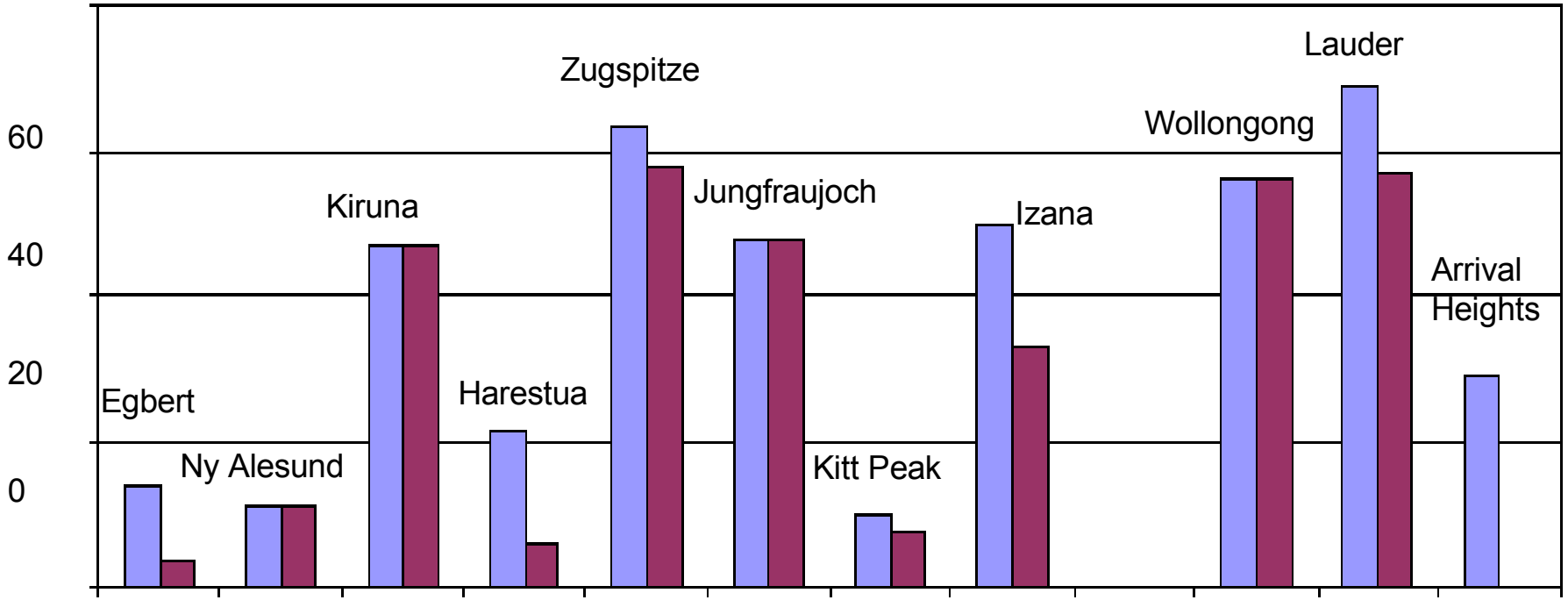
Long-term validation phase:

15 July 2002 – 15 Oct 2004: ***278 measurement days within 27 months***

= 2.3 measurement days / week.

Zugspitze FTIR: Relative Activity during Commissioning (15 Jul – 1 Dec 2002)

- Measurement Days 15 Jul – 1 Dec 02
- Data submitted to the Cal/Val data base 15 Jul – 1 Dec 02



Proc. ESA-ACVE1 Meeting, Dec 2002

Permanent Ground Truthing Facility Zugspitze/Garmisch according to the WMO requirements. Validation of and Synergistic use with Satellite Measurements

Trace gases

MAPS, MOPITT, SAGE, ENVISAT

Selected by EUMETSAT as European Site for operational AIRS/IASI Validation

Aerosols

Radiation

In situ
FTIR
IFU
GPS
UV
2964 m
Zugspitze
LIDAR
IFU
Radio sondes
LIDAR
FTIR
IFU
GPS
UV
In situ
Garmisch
734 m

Example:
2002 AIRSVAL Campaign
3-months-7-days-a-week operation
data delivery twice a day within 12 h

Zugspitze FTIR: Quality control/intercomparison

(taken from "Zugspitze FTIR NDSC Report Form 2003"):

Name, date, and location of last intercomparison and/or validation:

•1996 intercomparison with Jungfraujoch: coincident measurements and independent analyses of HF, HCl. Agreement within 2 per cent

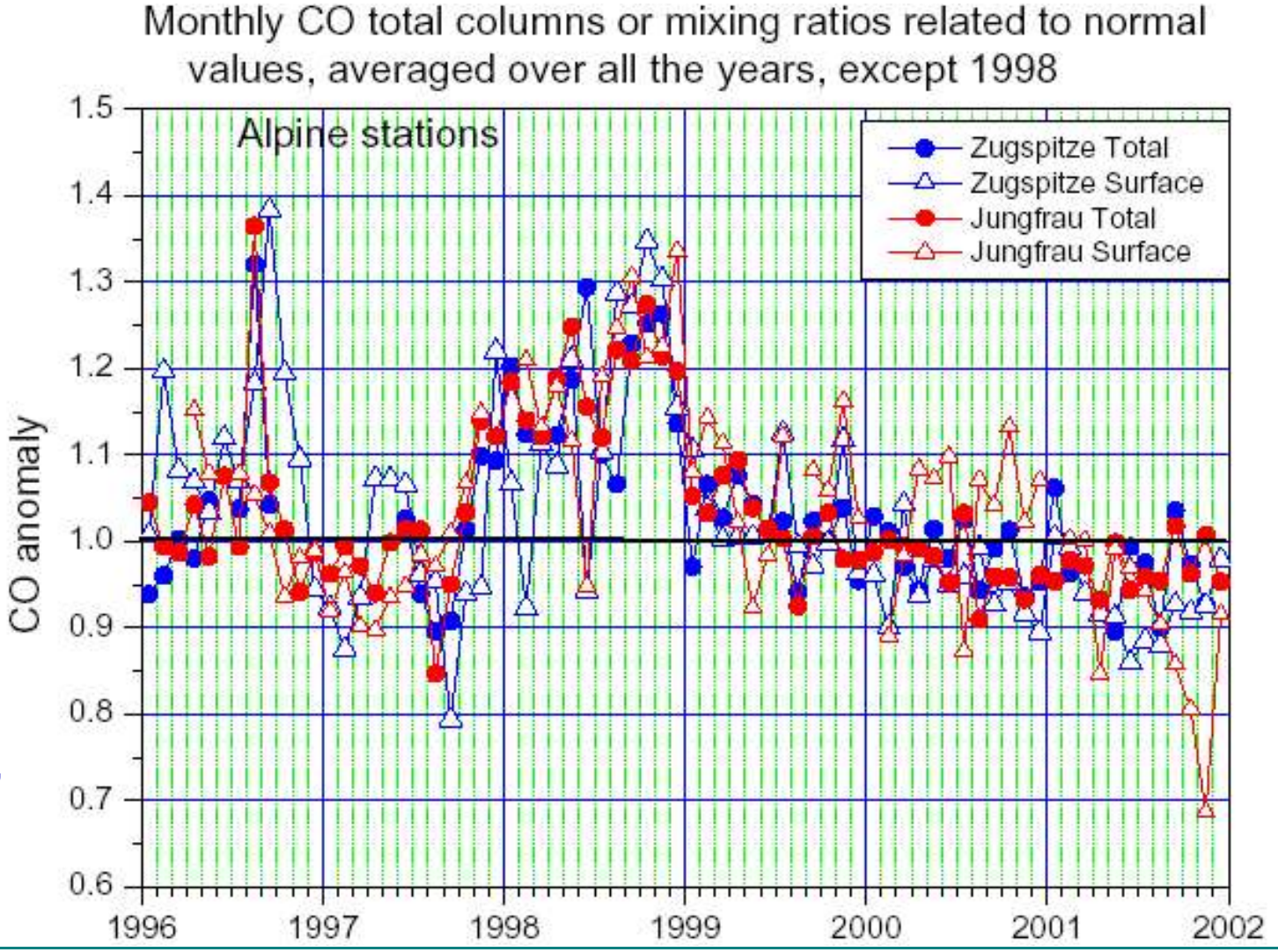
•In 2001 evaluation of the Zugspitze time series since 1995 of HCl and ClONO2, and comparison to the Jungfraujoch series; showed very good overall agreement!

•In spring 2003 comparison of the Zugspitze time series (1996-2002) of CO to the Jungfraujoch series; showed very good overall agreement!

•Intense 3 months water vapor validation campaign at Zugspitze (mid Aug – mid Nov 2002) with permanent FTIR water vapor measurements compared to 4 radio sondes launched on site daily and permanent GPS water column measurements on site. Very good agreement of FTIR to sonde columns within a few per cent! Detailed FTIR validation study also relative to GPS measurements under way._

Zugspitze FTIR: Quality control/intercomparison

Example CO



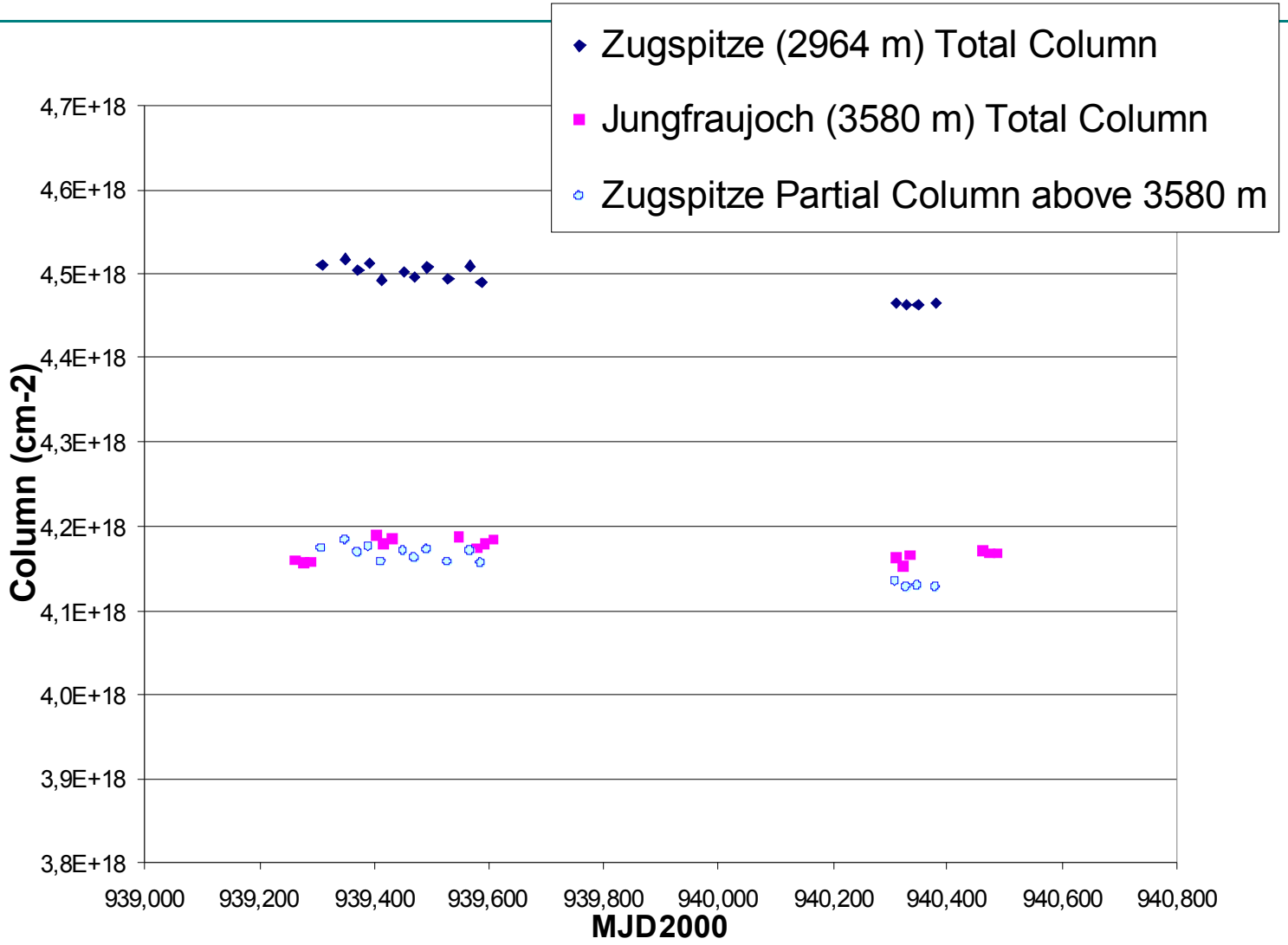
Yurganov, et al.,
J. Geophys. Res. 109, 2004

Zugspitze FTIR: Quality control/intercomparison

Example N_2O

+

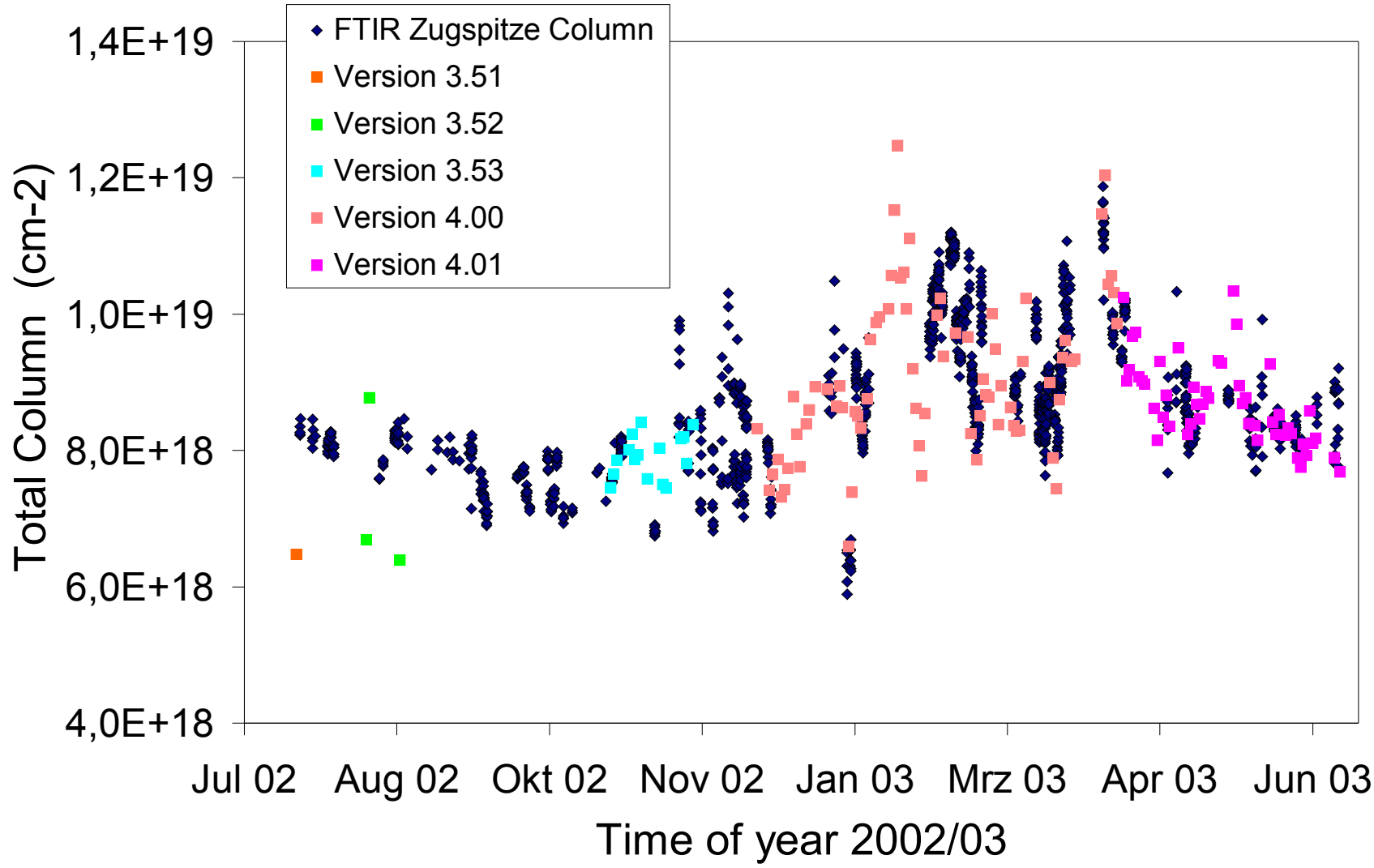
also done for all other species!



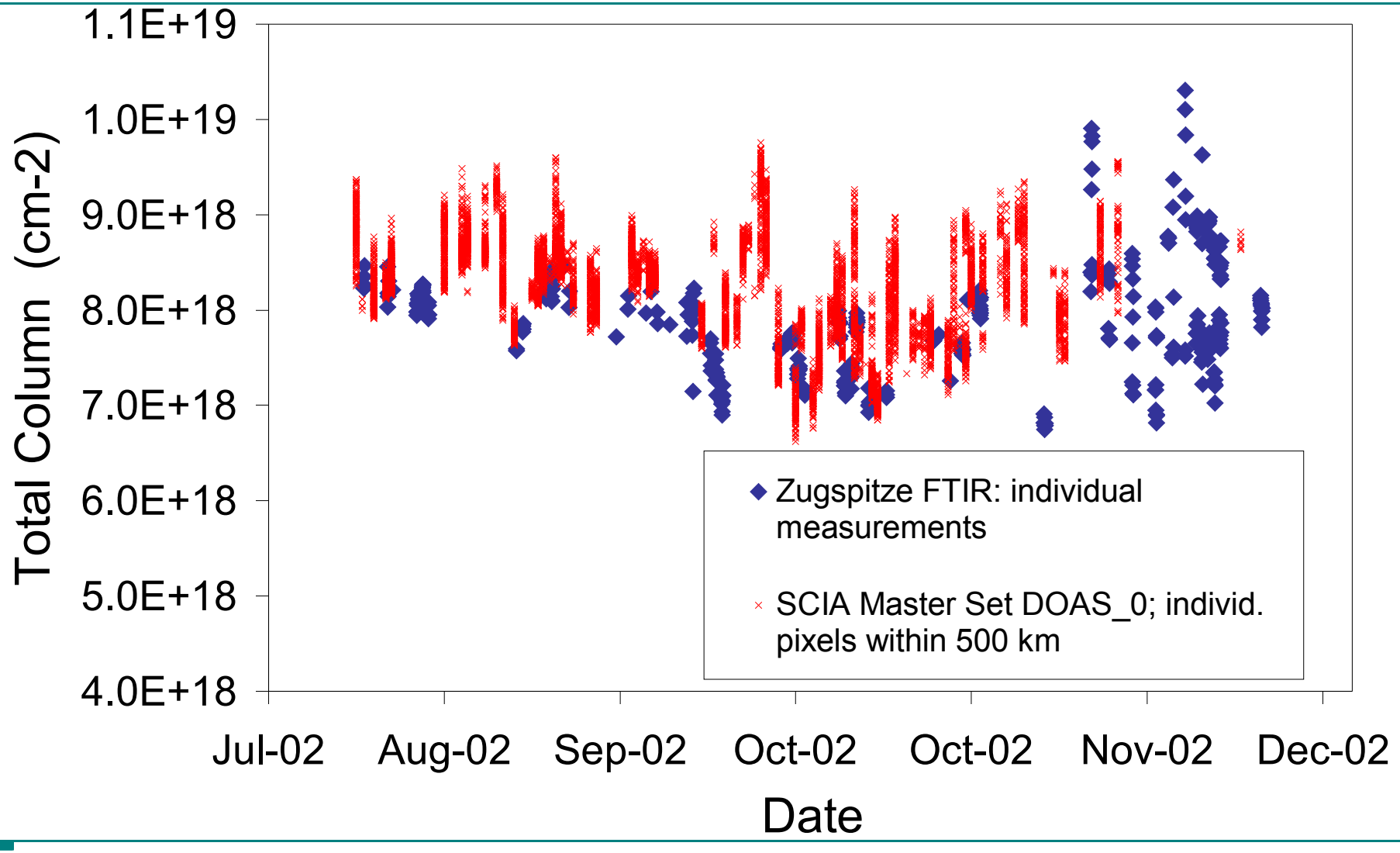
Ozone Operational NRT Product - July 2003: FTIR versus SCIA DOAS0 (UV)

FTIR: Individual measurements (15-min integr.)

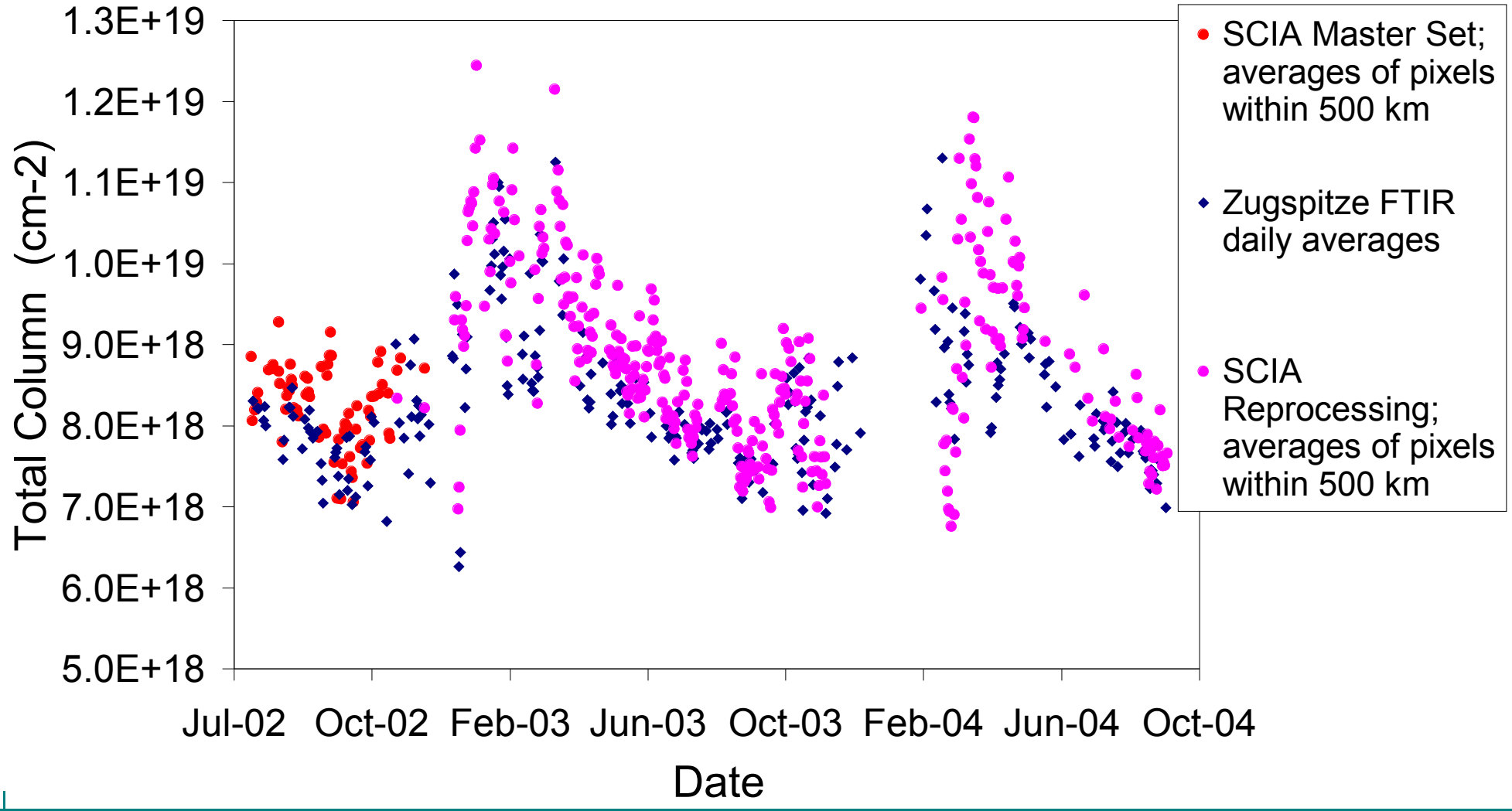
SCIA: Daily average of all pixels within 500-km radius



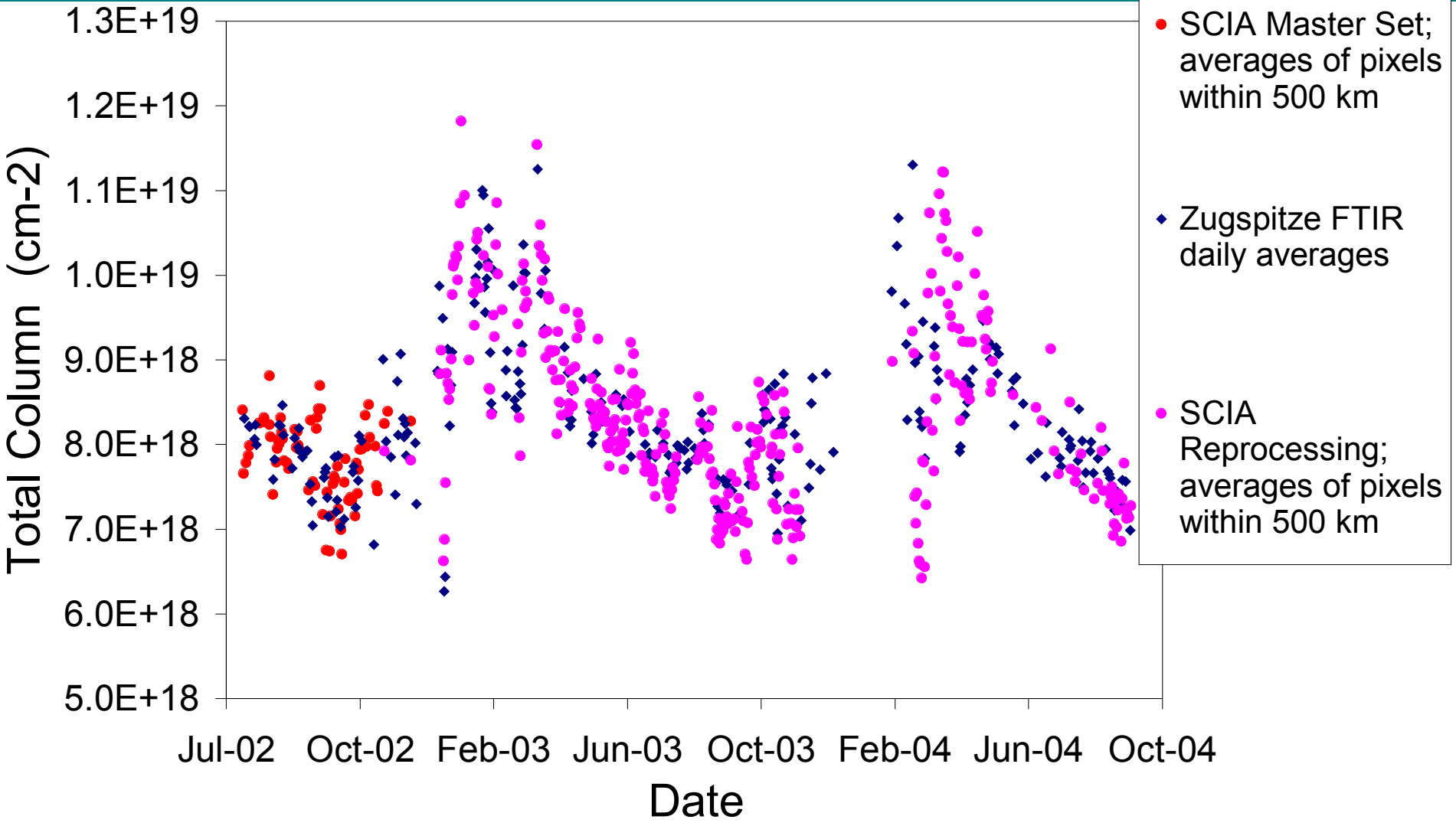
Ozone Operational Product - April 2004: FTIR versus SCIA Master Set



Ozone Operational – Dec 2004: FTIR versus SCIA Master Set and Reprocessing



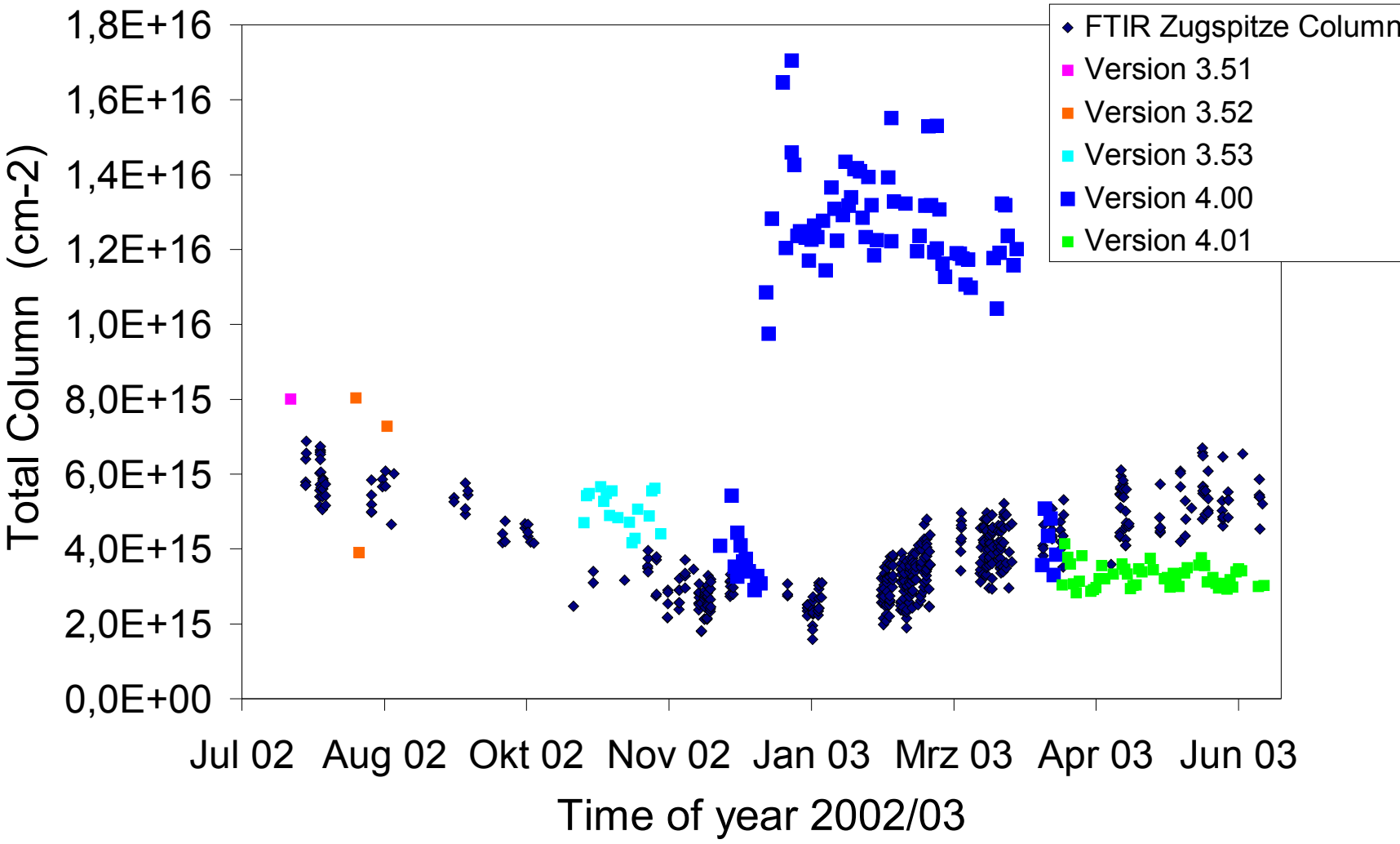
O_3 Column Scaling Factor: FTIR = (SCIA Master Set, Reprocessing) * 0.95(±0.01)



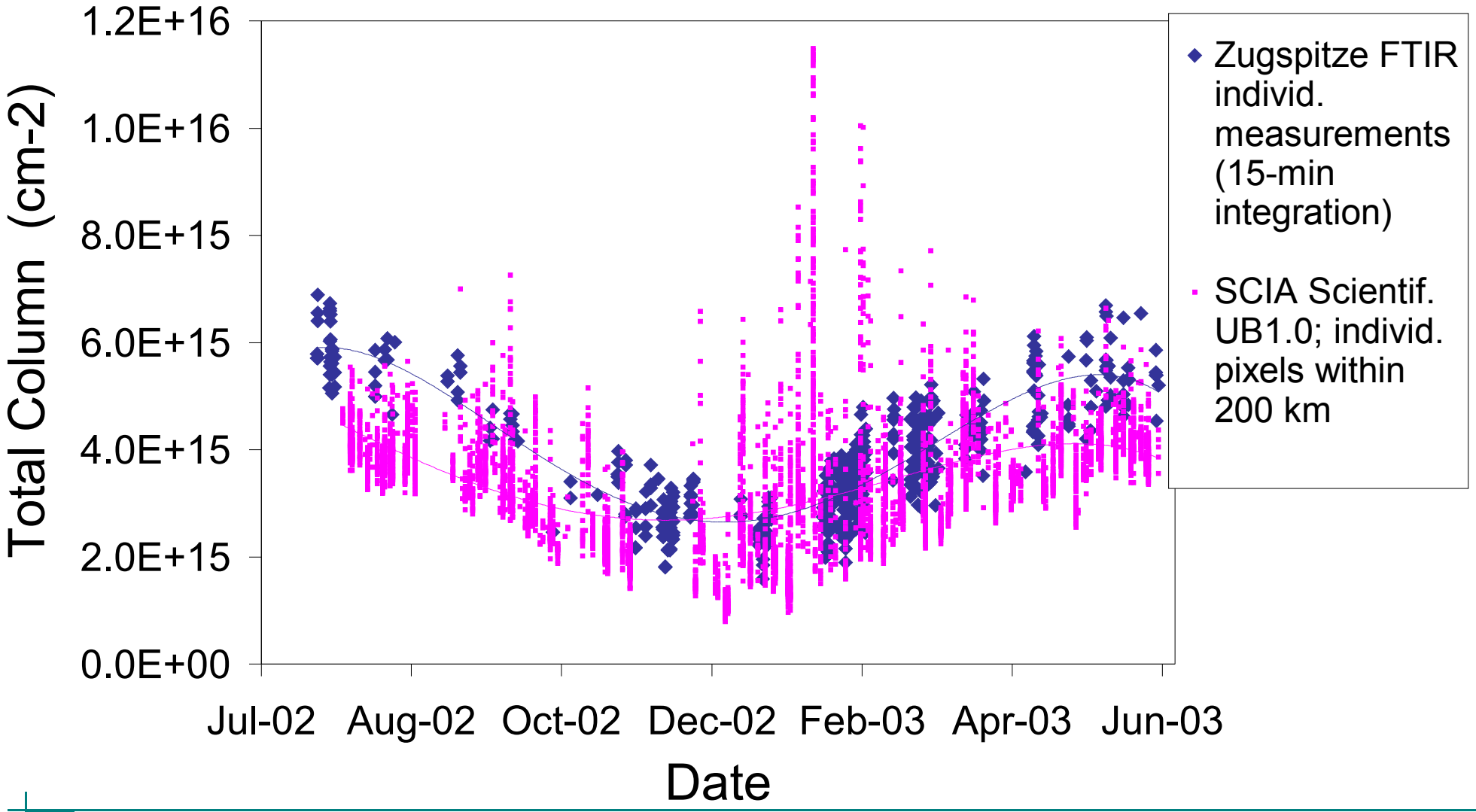
NO_2 Operational NRT Product – July 2003: FTIR versus SCIA DOAS1 (vis)

FTIR: Individual measurements (15-min integr.)

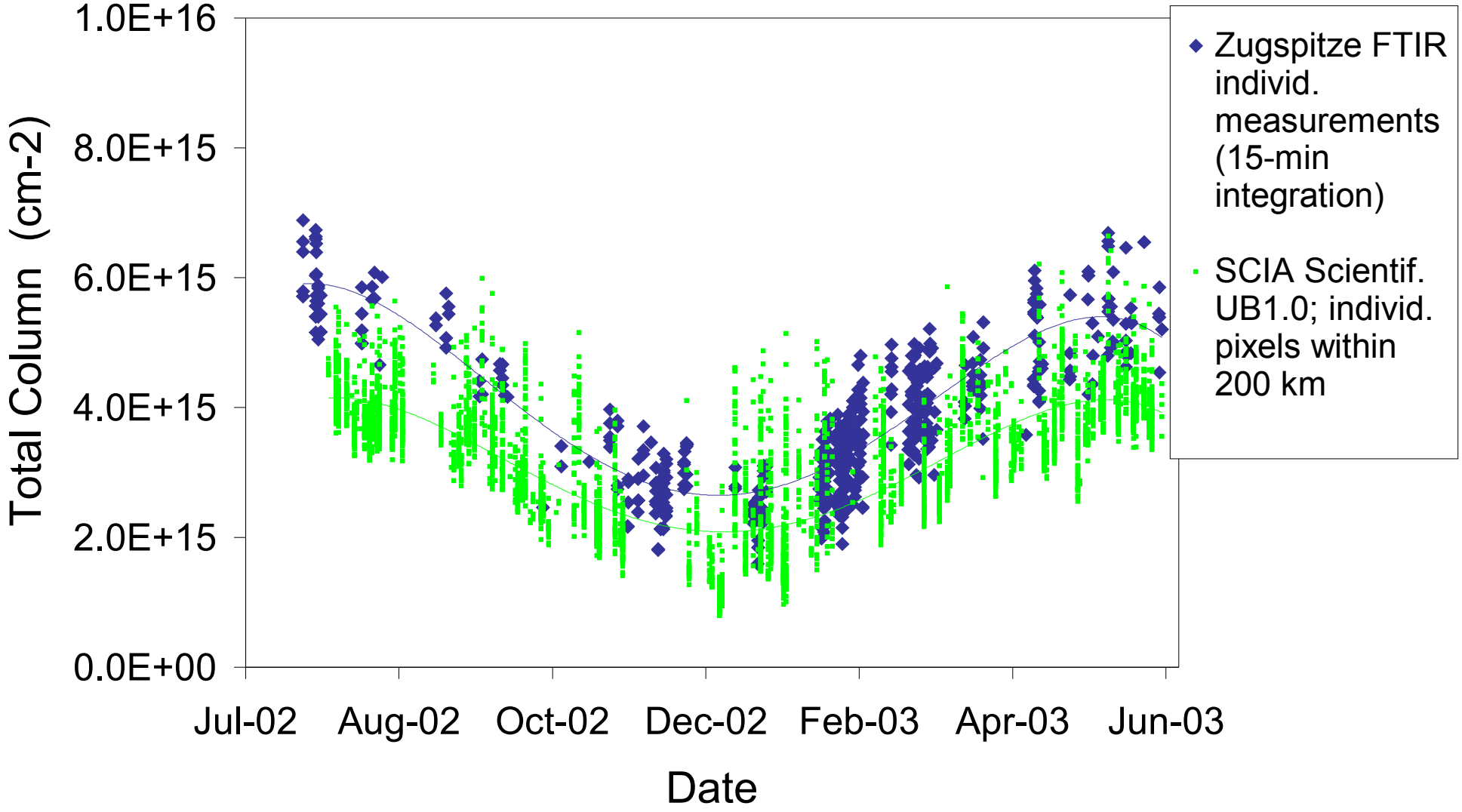
SCIA: Daily average of all pixels within 500-km radius



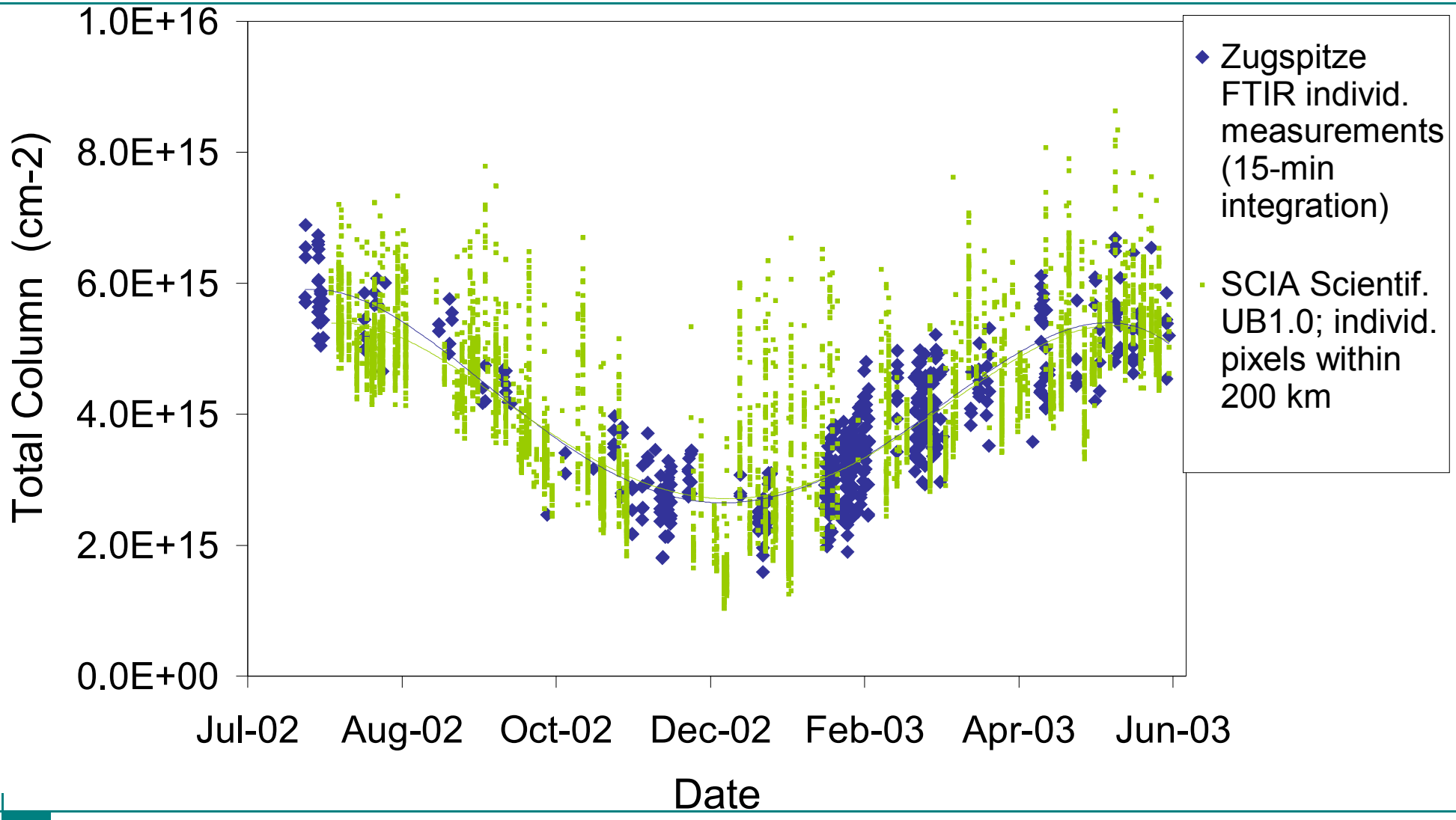
NO_2 Scientific Product UB 1.0 – July 2003: FTIR versus UB 1.0



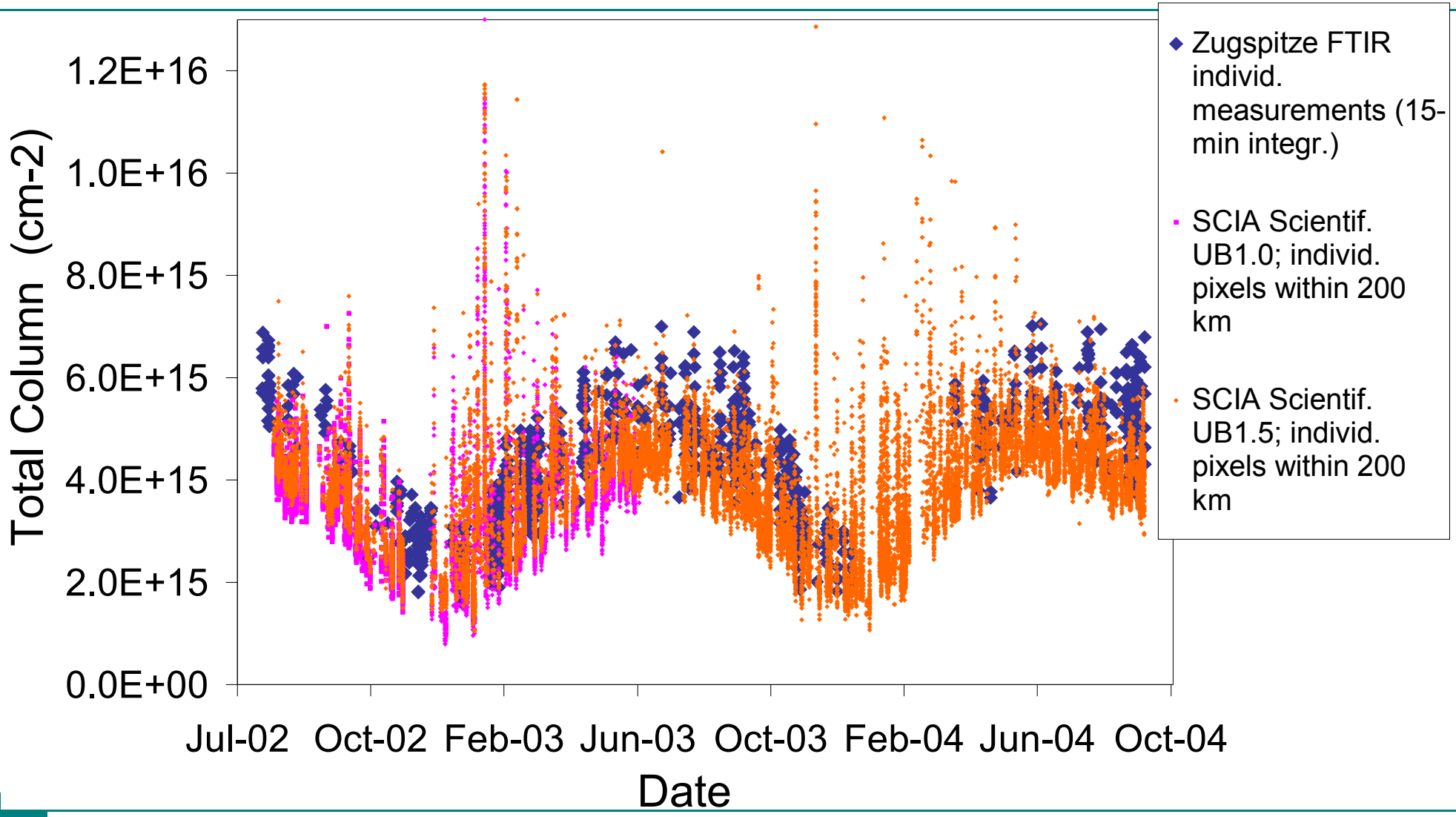
NO_2 Scientific Prod. UB1.0: Pollution episodes removed from satellite data



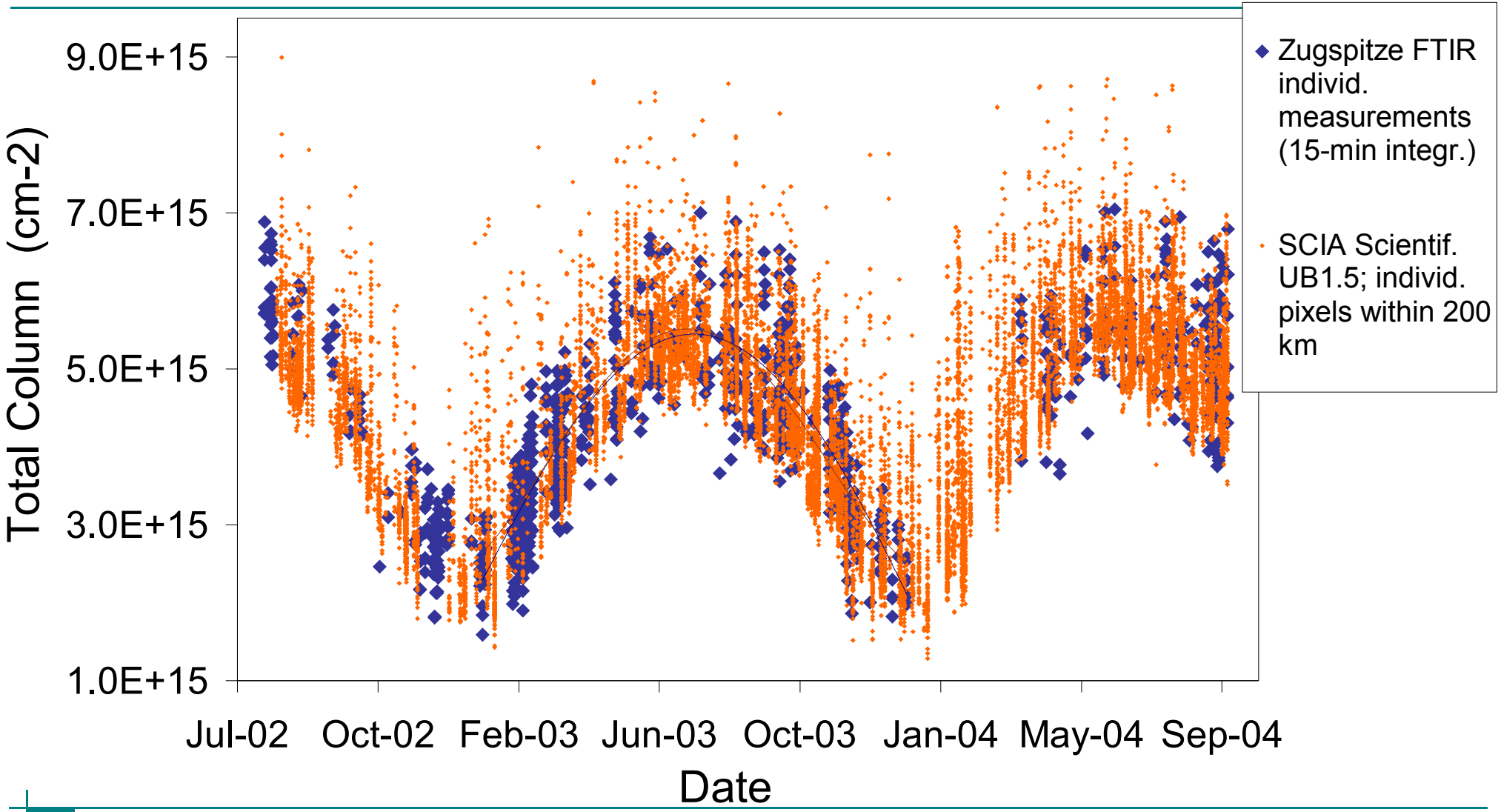
NO_2 Column Scaling Factor: FTIR = SCIA UB 1.0 * 1.30(±0.02)



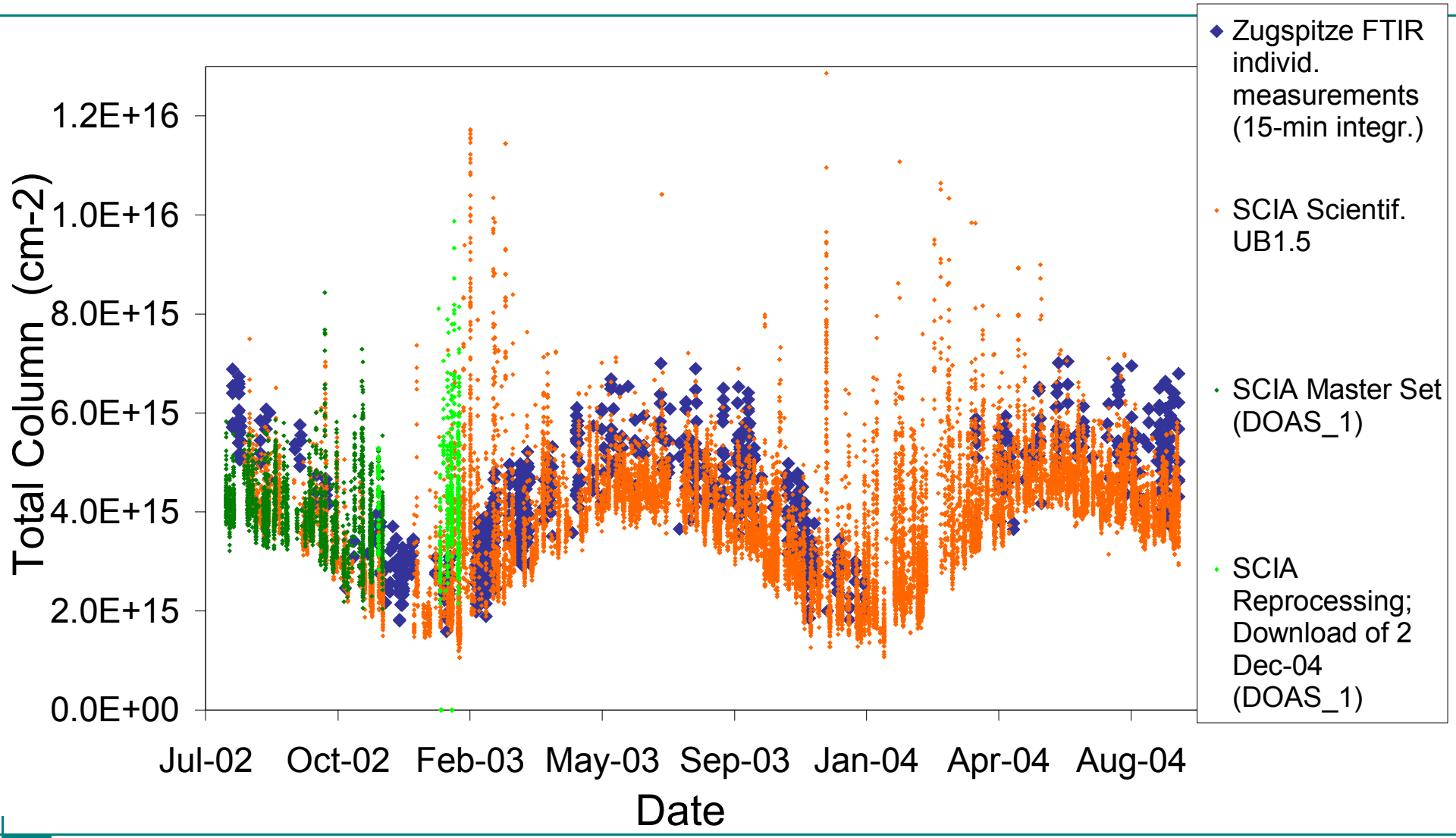
NO_2 Scientific – 2004: FTIR versus UB 1.5 (1E+15 slant col. added) and UB 1.0



2nd NO_2 Column Scaling Factor: FTIR = SCIA UB 1.5 * 1.20(±0.02)



NO_2 Operational Product - 2004: Master Set, Reprocessing versus UB 1.5, FTIR



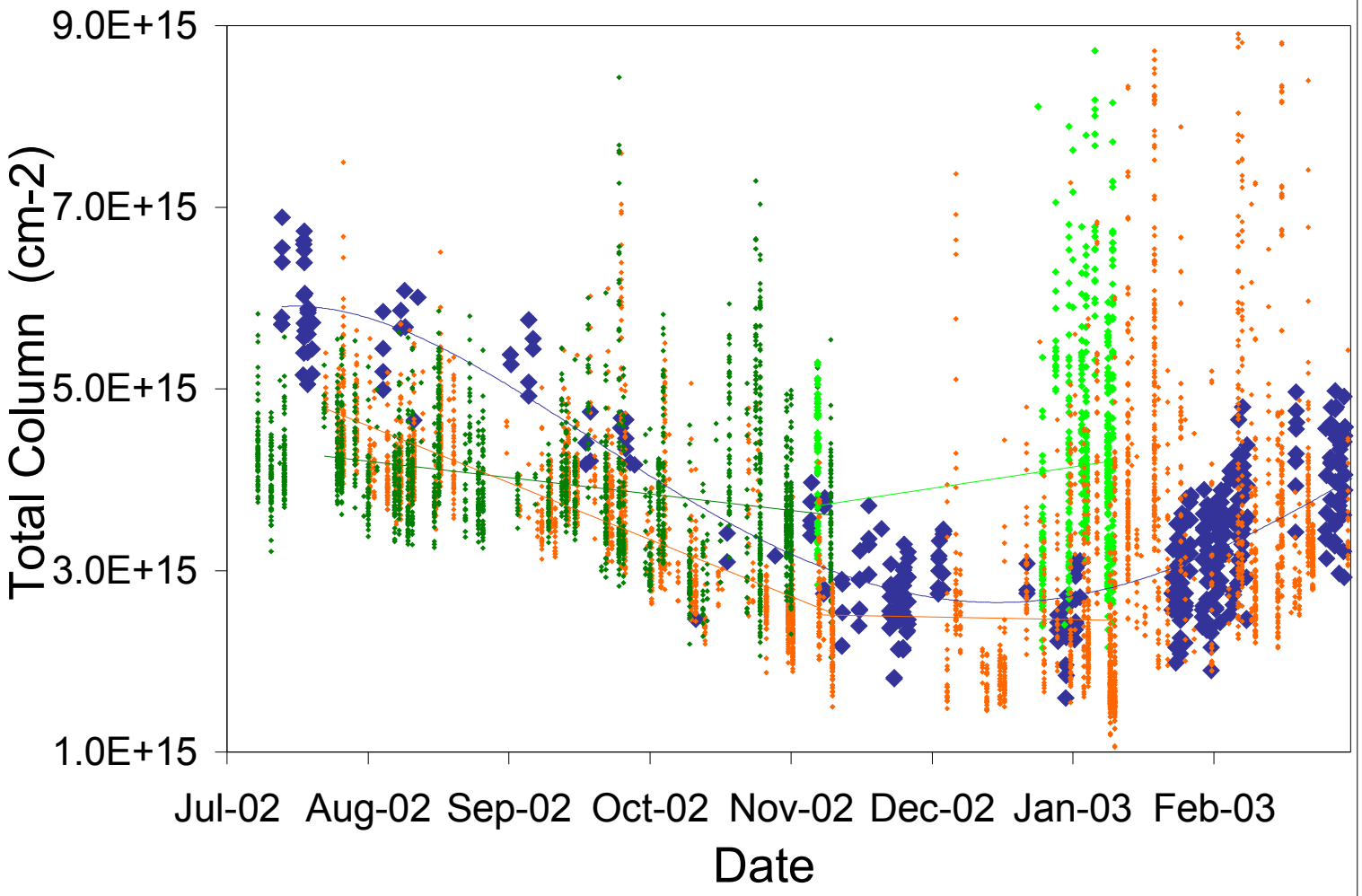
IMK-IFU Garmisch-Partenkirchen, Ralf Sussmann

Karlsruhe Research Center

Zugspitze FTIR NDSC

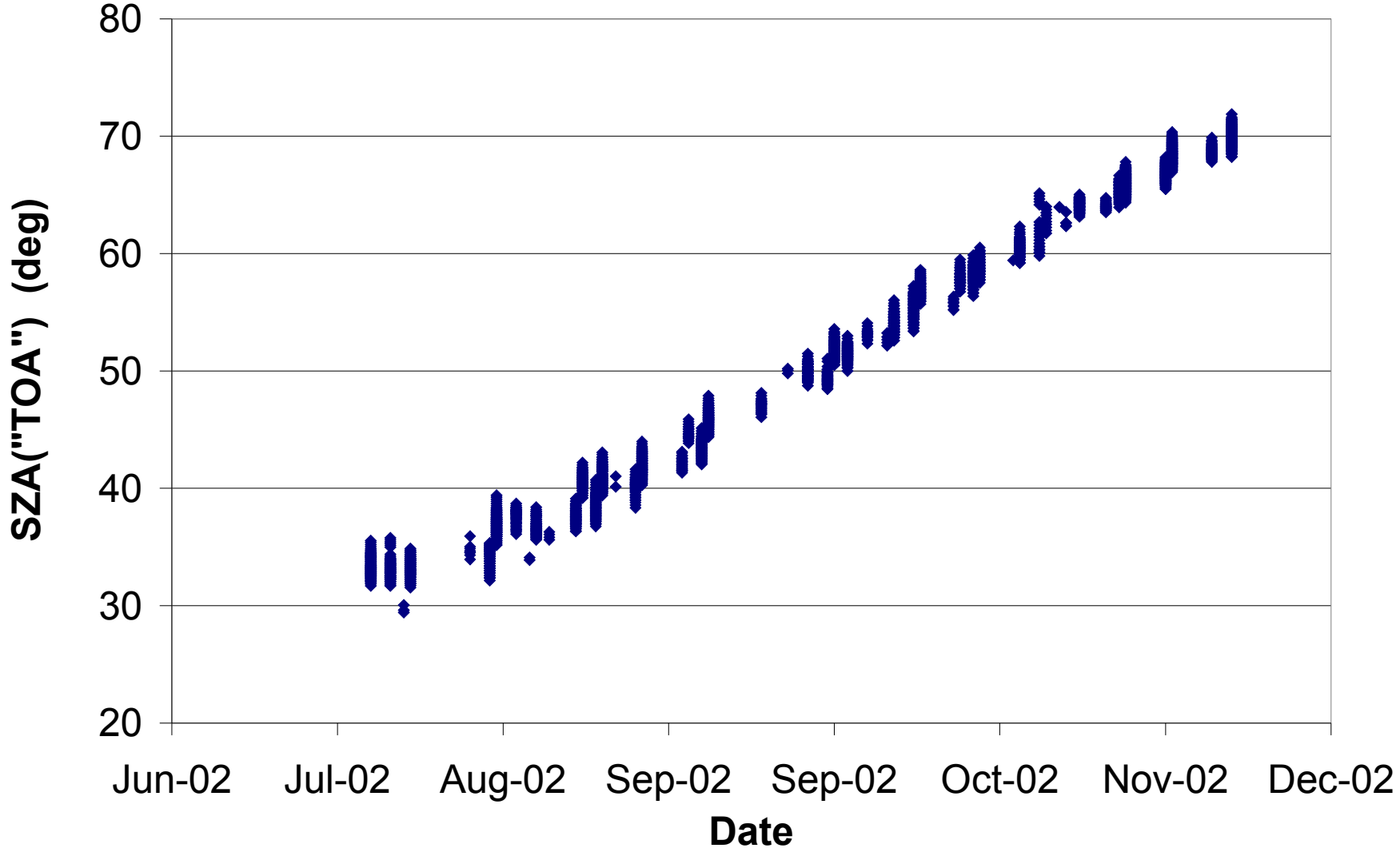
DLR Contr. 50 EE 0007

NO_2 Operational Product - 2004: Master Set, Reprocessing versus UB 1.5, FTIR

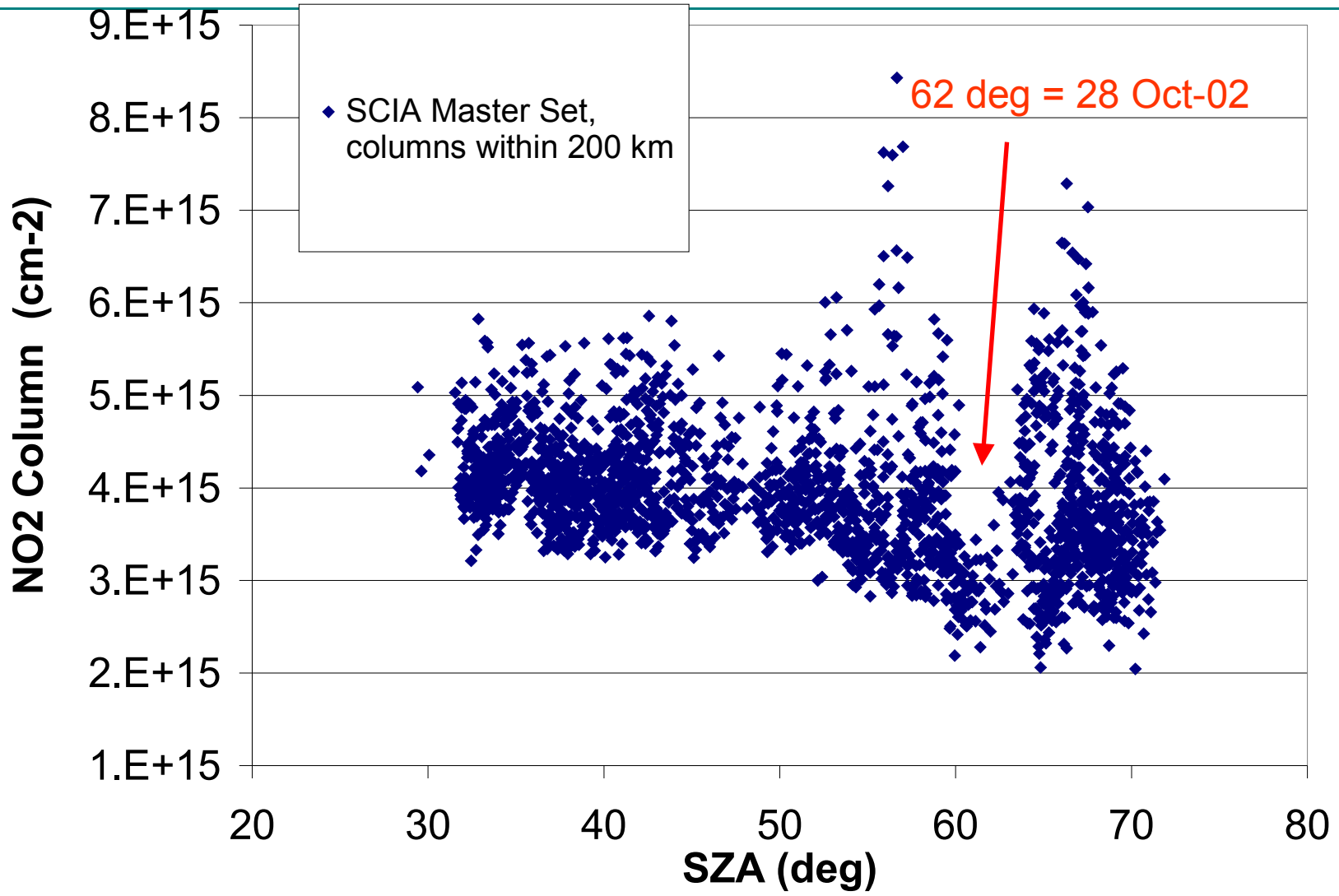


- Zugspitze FTIR individ. measurements (15-min integr.)
- SCIA Scientif. UB1.5
- SCIA Master Set (DOAS_1)
- SCIA Reprocessing; Download of 2 Dec-04 (DOAS_1)

NO_2 Operational Product - Wrong Annual Cycle: Role of Solar Zenith Agle



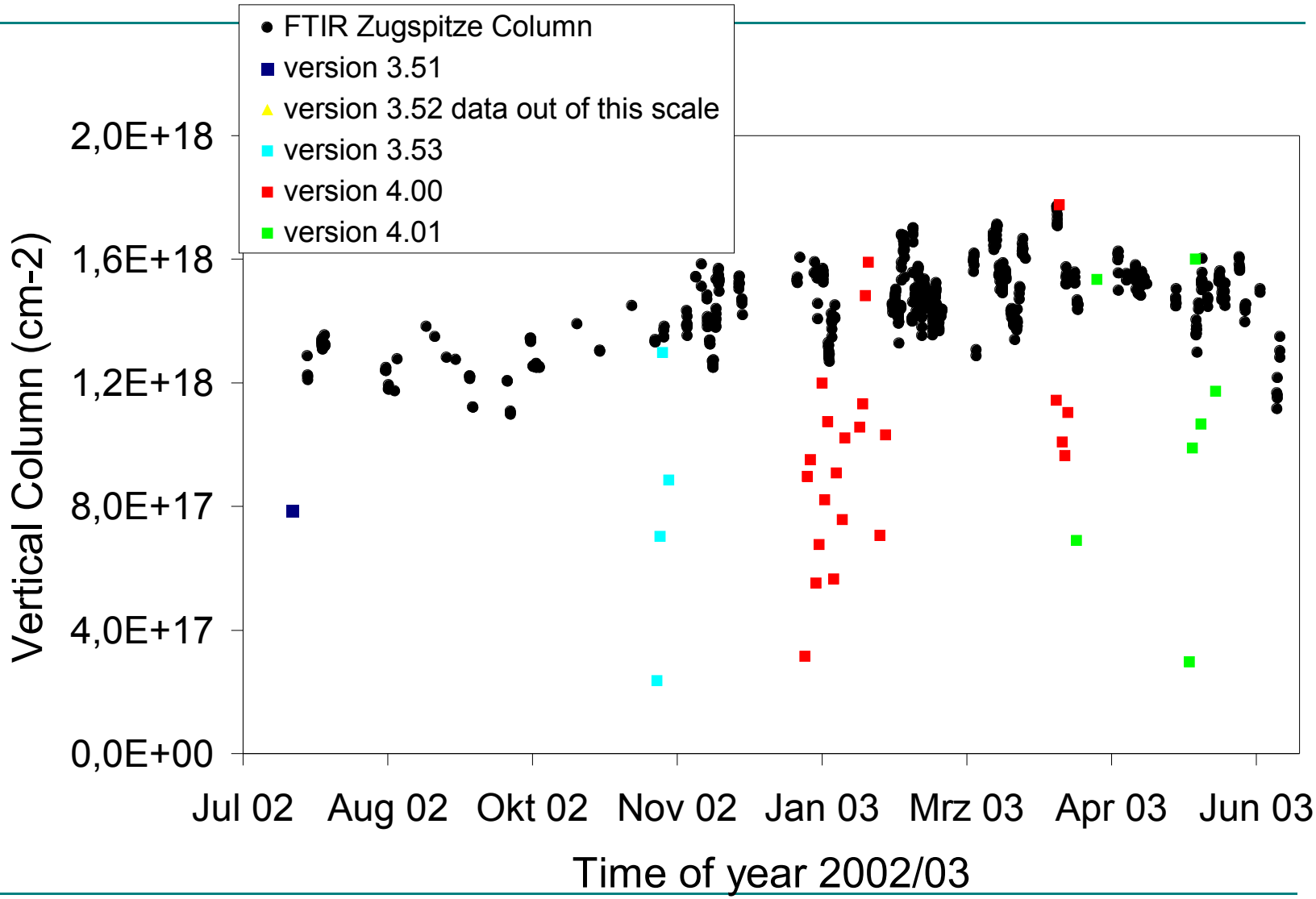
NO_2 Operational Product - Wrong Annual Cycle: Zenith Angle Dependence



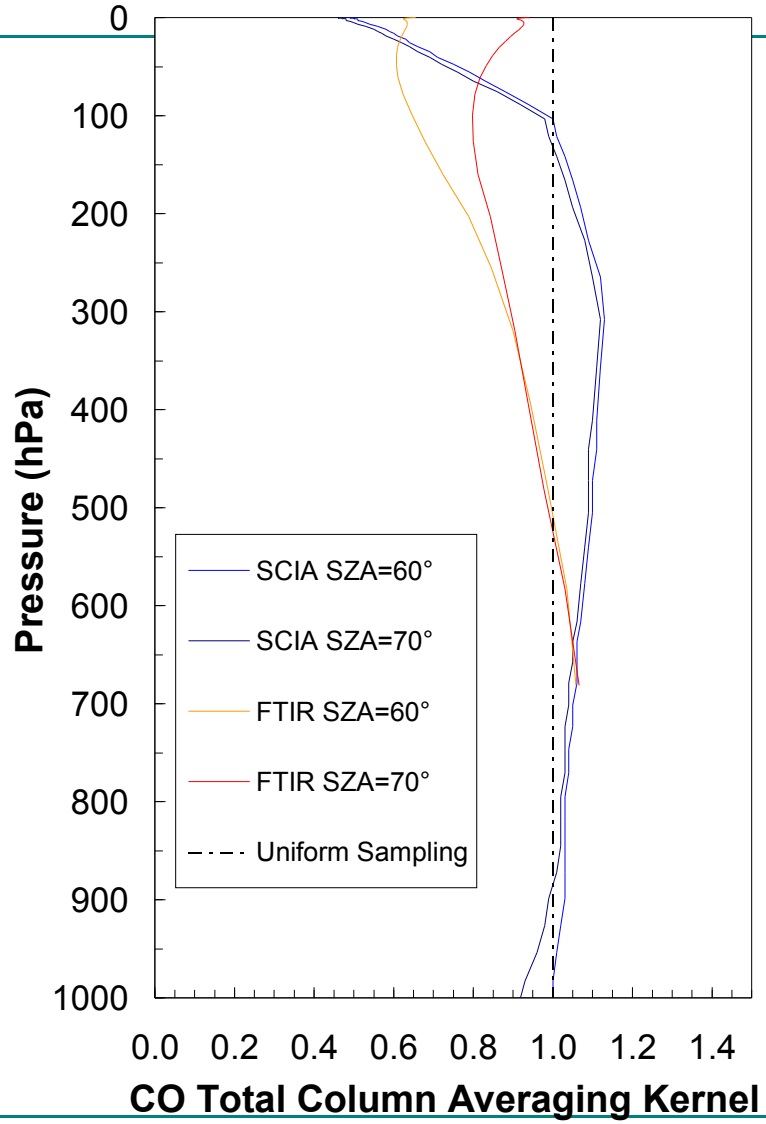
CO Operational NRT Product Versions July-2003: FTIR versus SCIA BIAS2 (NIR)

FTIR: Individual measurements (15-min integr.)

SCIA: Daily average of all pixels within 500-km radius

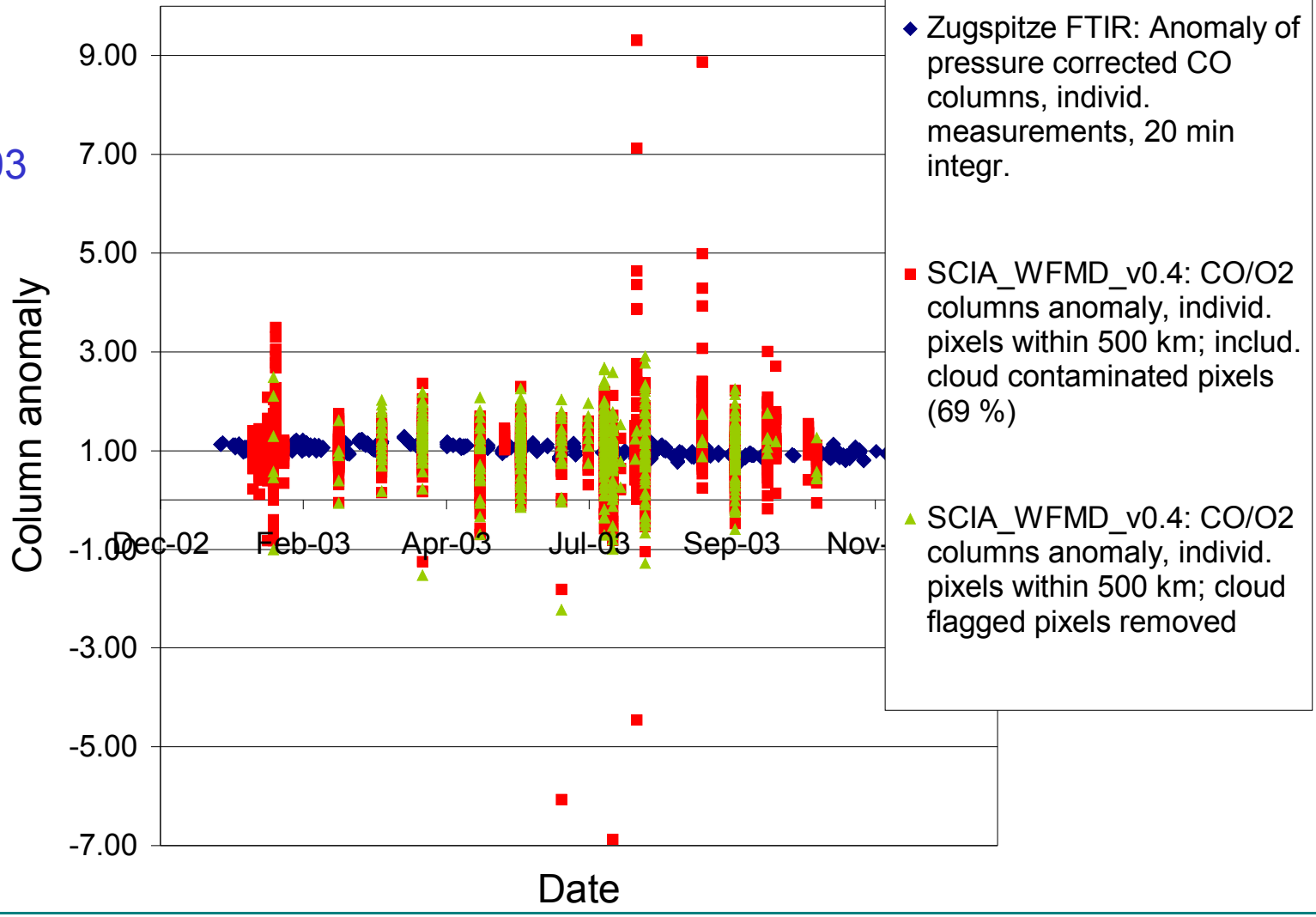


CO Scientif. WFMD v0.4 Prod.: FTIR versus WFMD Averaging Kernels

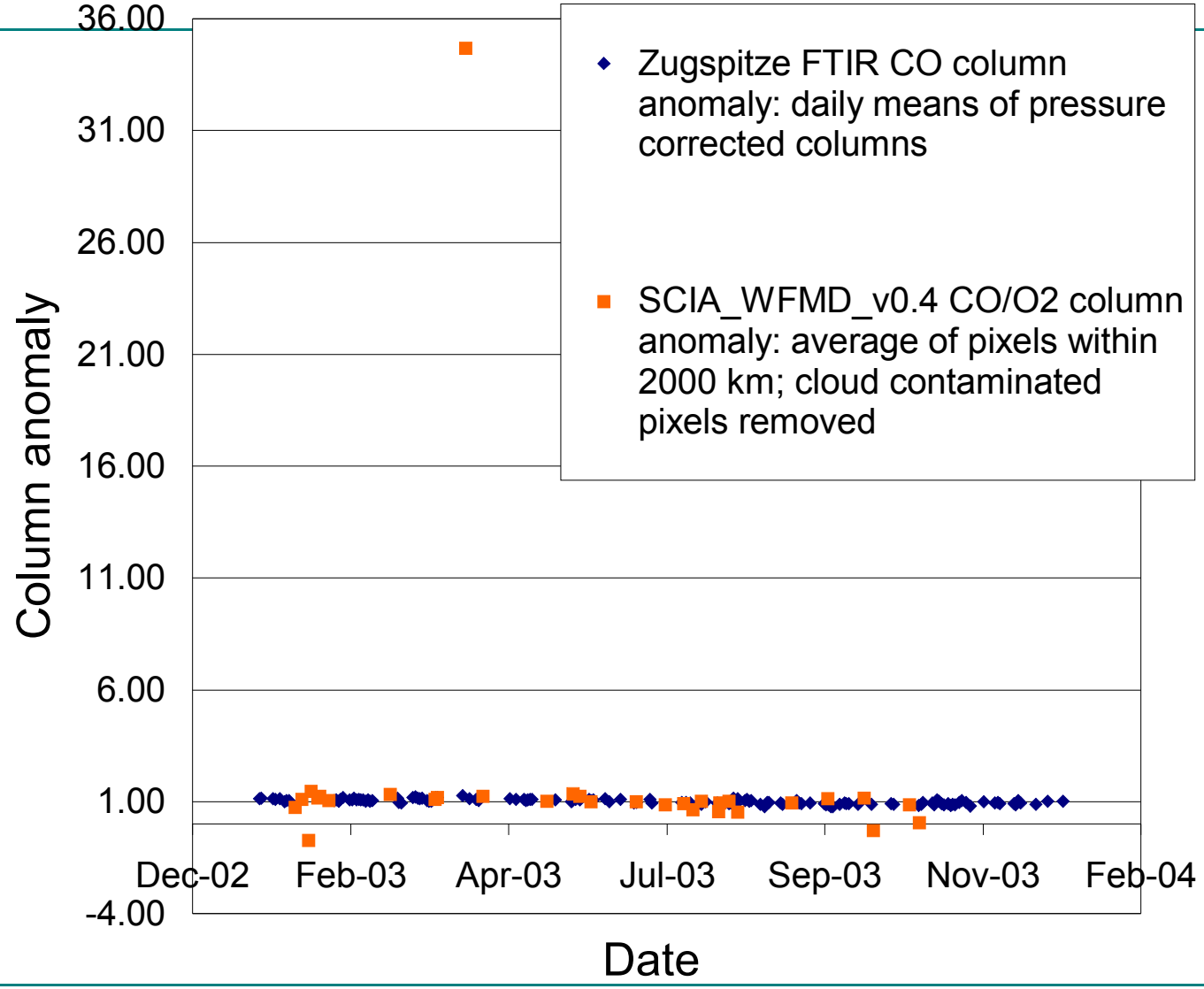


CO WFMD v0.4: FTIR indiv. measurements versus WFMD indiv. pixels <500 km

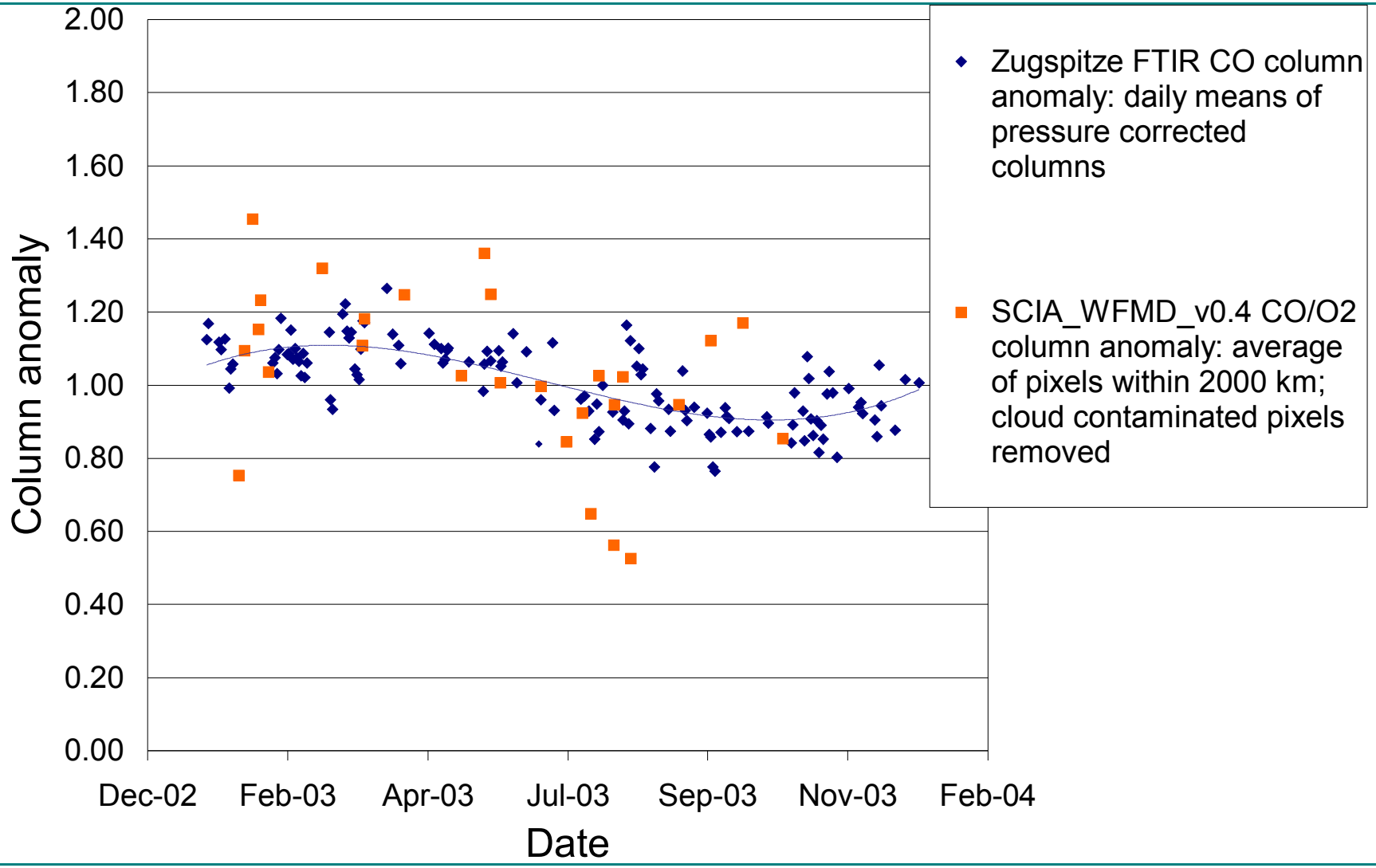
WFMD data
for 33 days
Jan–Oct 2003



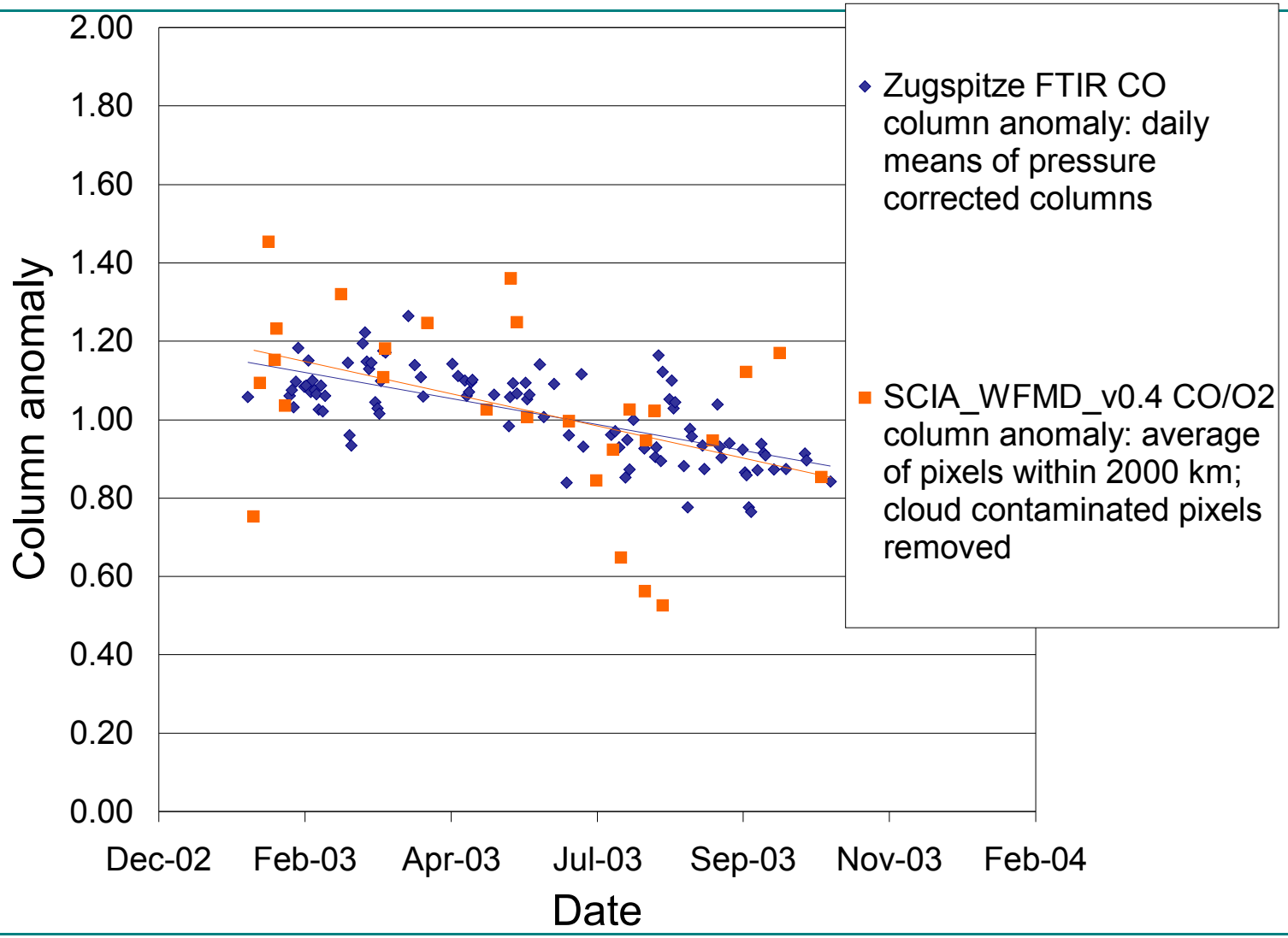
CO WFMD v0.4: FTIR daily averages versus WFMD pixel averages <2000 km



CO WFMD v0.4: FTIR daily averages versus WFMD pixel averages <2000 km



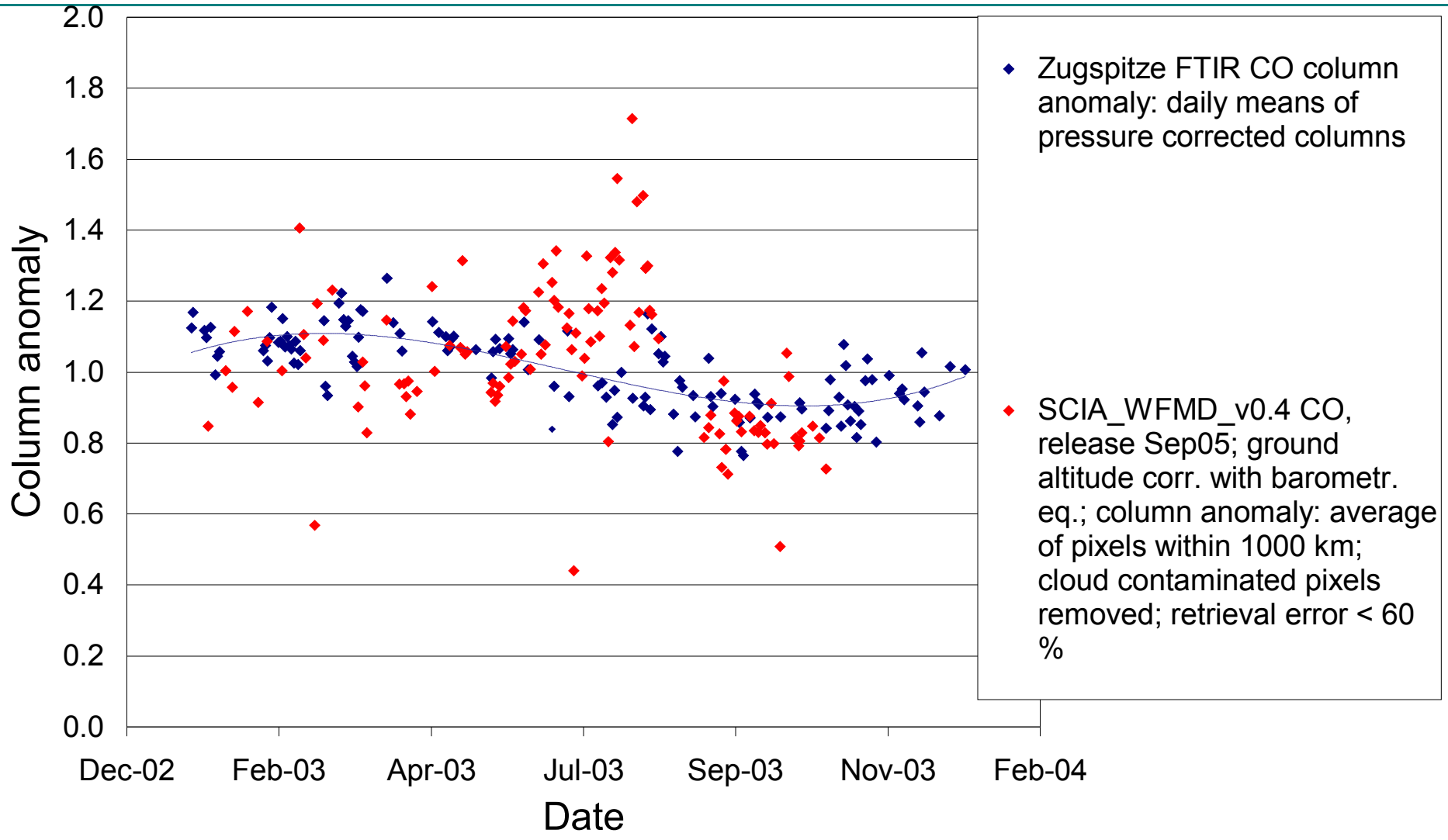
CO WFMD v0.4: FTIR daily averages versus WFMD pixel averages <2000 km



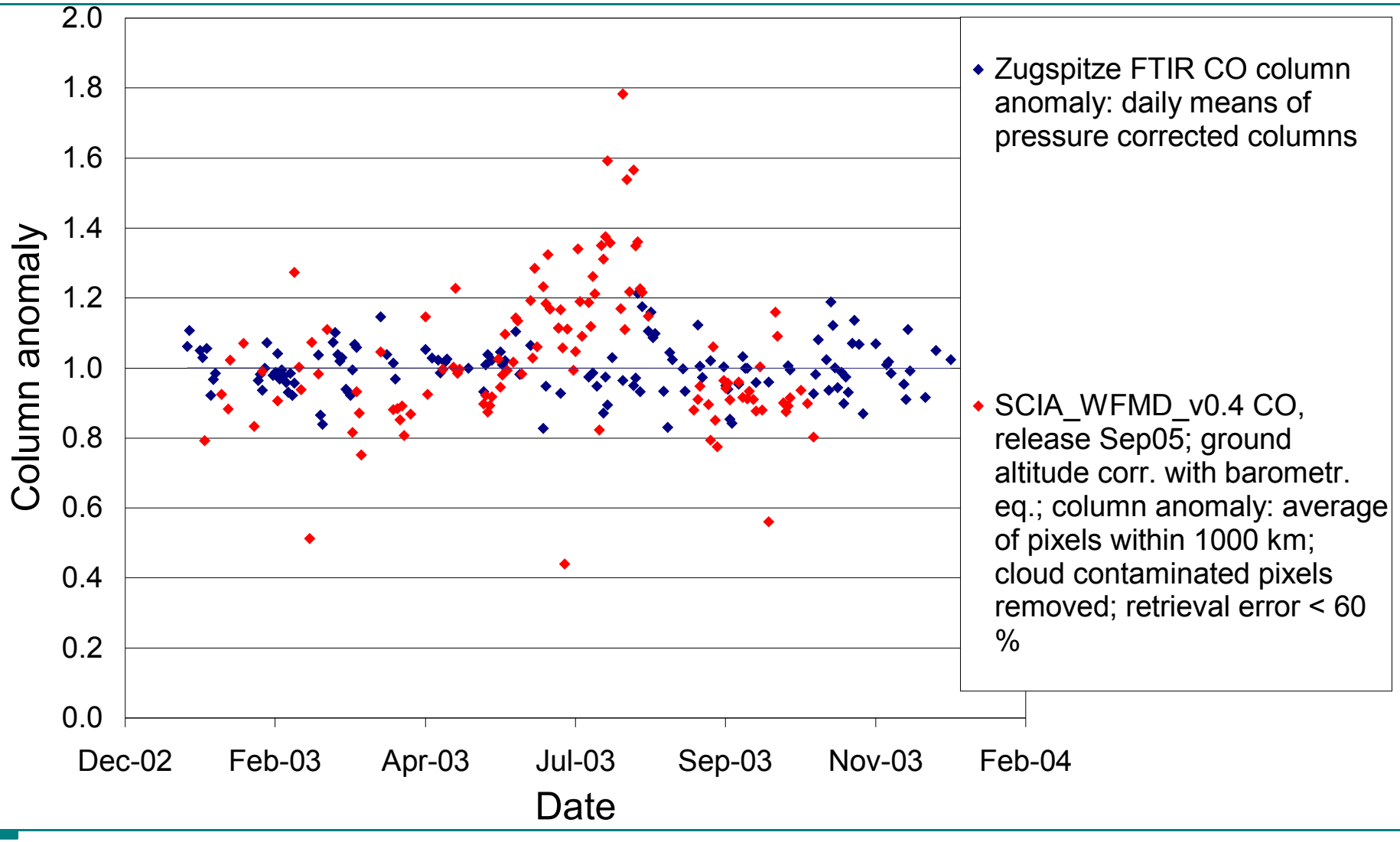
CO WFMD v0.4: Linear Response to Annual Cycle?

	Slope	Slope error	R
Zugspitze FTIR	-9.5E-4	⑥9.8E-5	-0.70
SCIA 2000 km	-1.2E-3	⑥4.9E-4	-0.43
SCIA 1000 km	-6.4E-4	⑥5.9E-4	-0.21
SCIA 1000 km incl. clds	-4.4E-4	⑥4.3E-4	-0.18

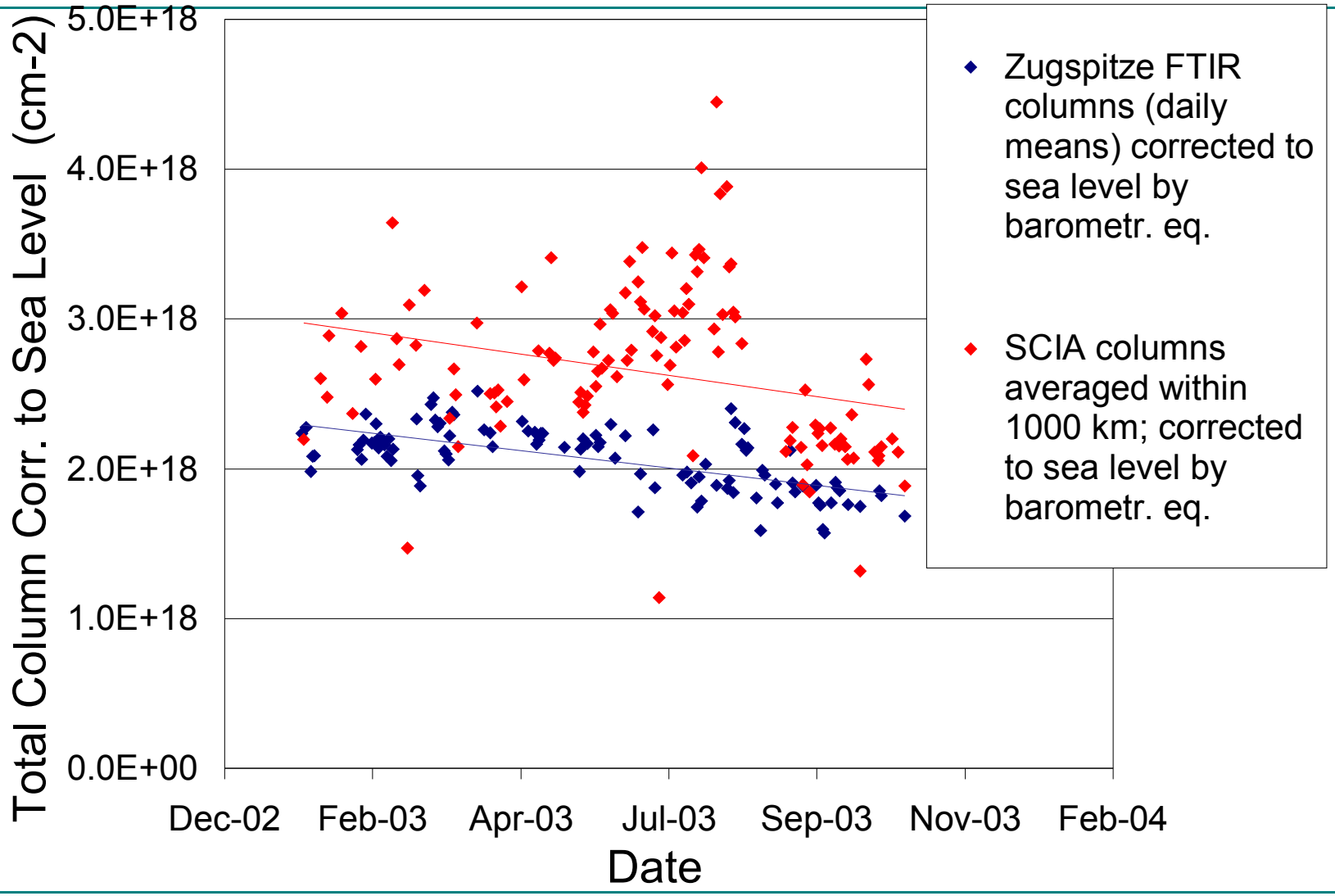
CO WFMD Sep-04 „Add-Release“: Data Set increased from 33 Days to 153 Days



CO Day-to-Day Scatter: STDV FTIR = 7.3 % STDV SCIA WFMD v0.4 = 25.4 %



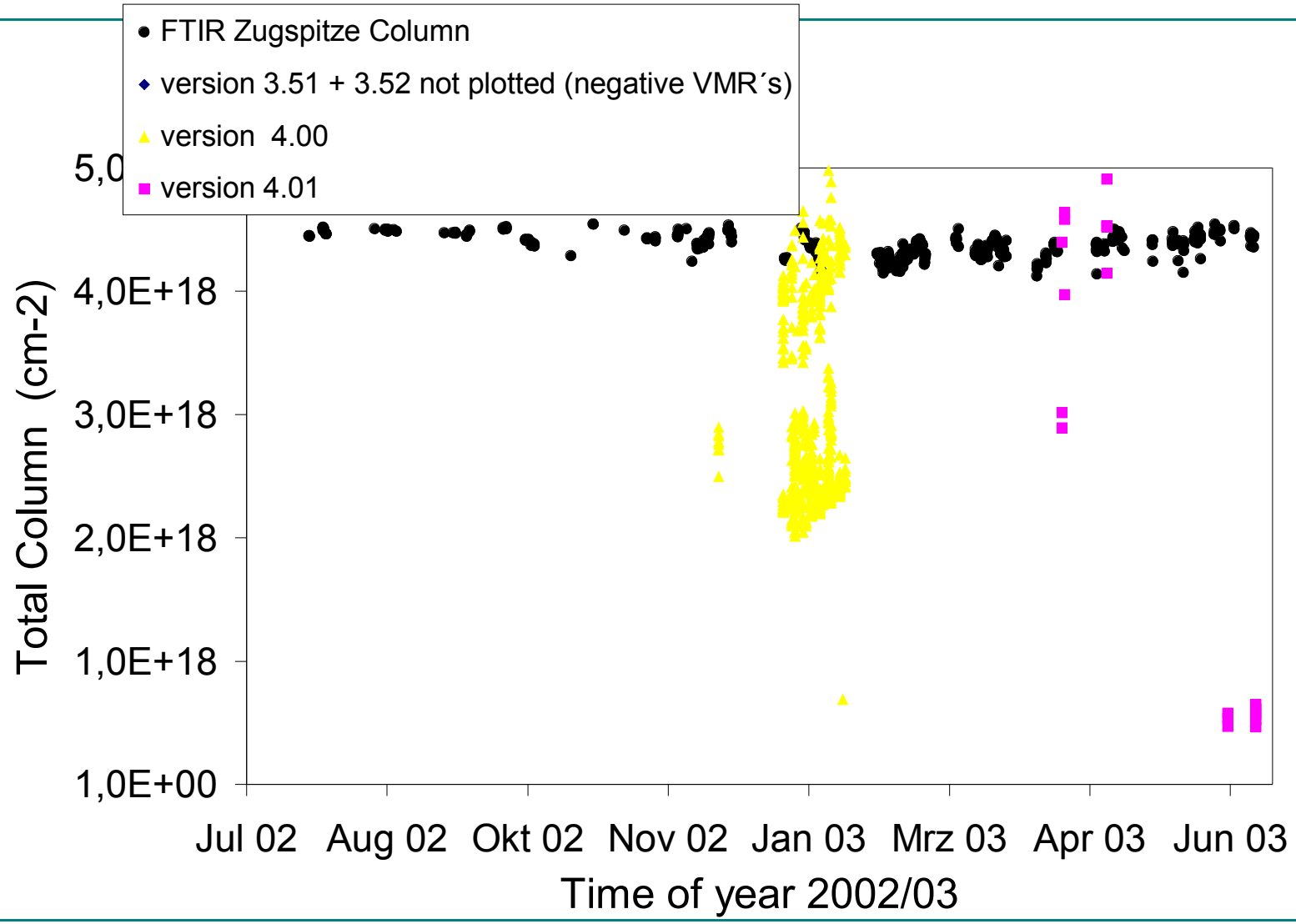
CO Column Scaling Factor: Zugspitze FTIR = SCIA WFMD v0.4 * 0.78(± 0.06)



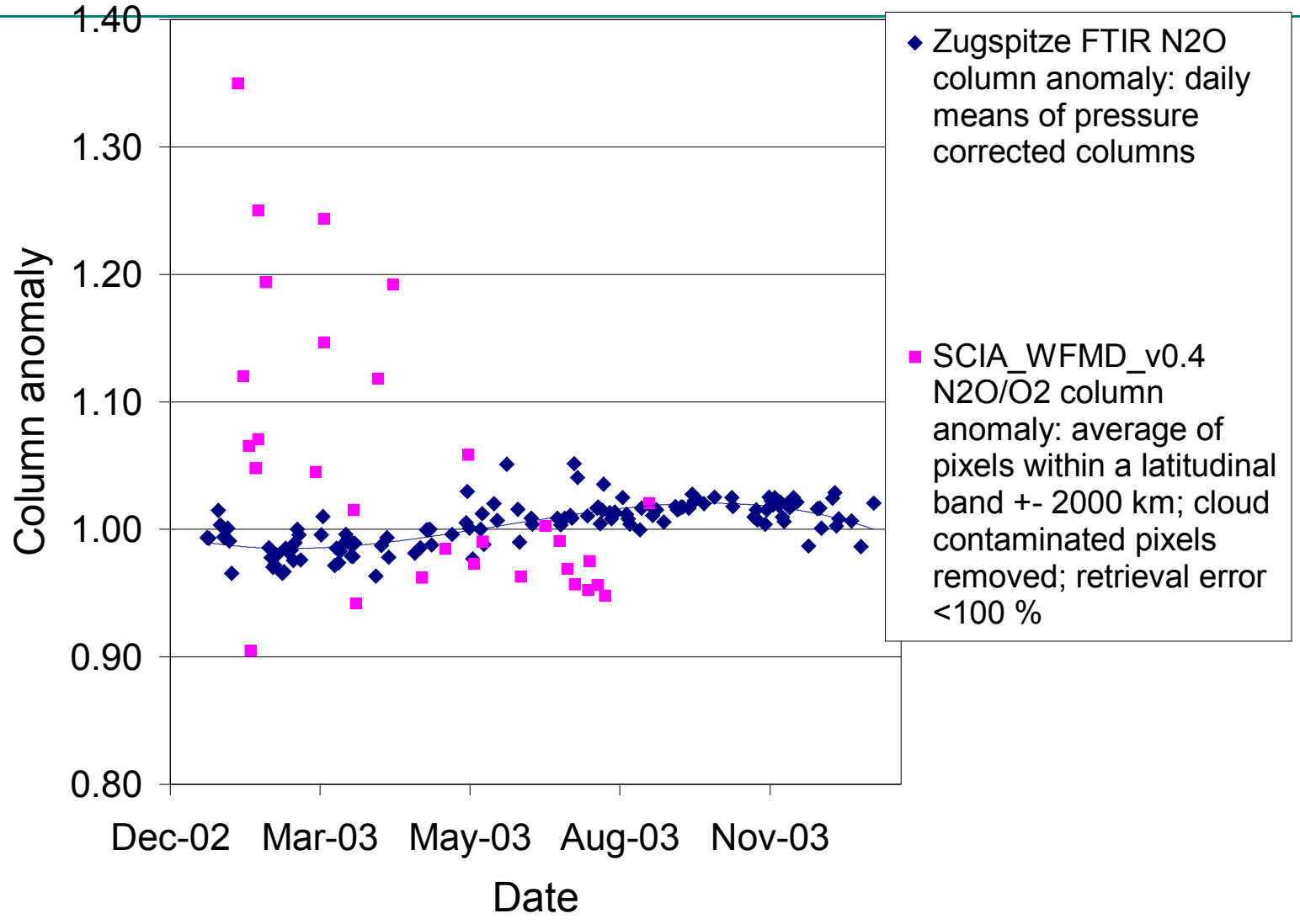
N_2O Operational NRT Product July-2003: FTIR versus SCIA BIAS1 (NIR)

FTIR: Individual measurements (15-min integr.)

SCIA: Individual pixels within 500-km radius



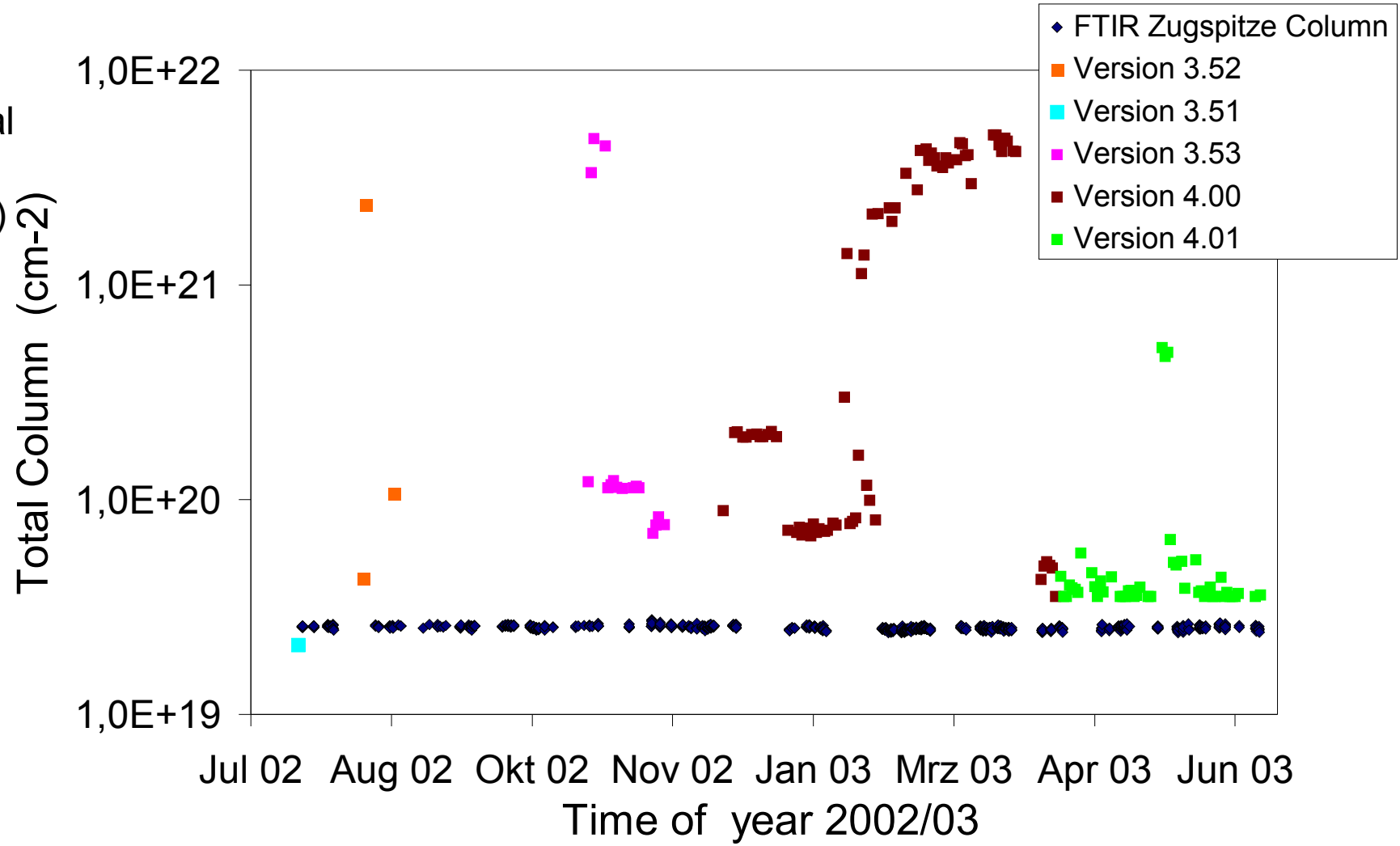
N_2O Scientif. WFMD v0.4: FTIR versus WFMD < ±2000 km latitudinal band



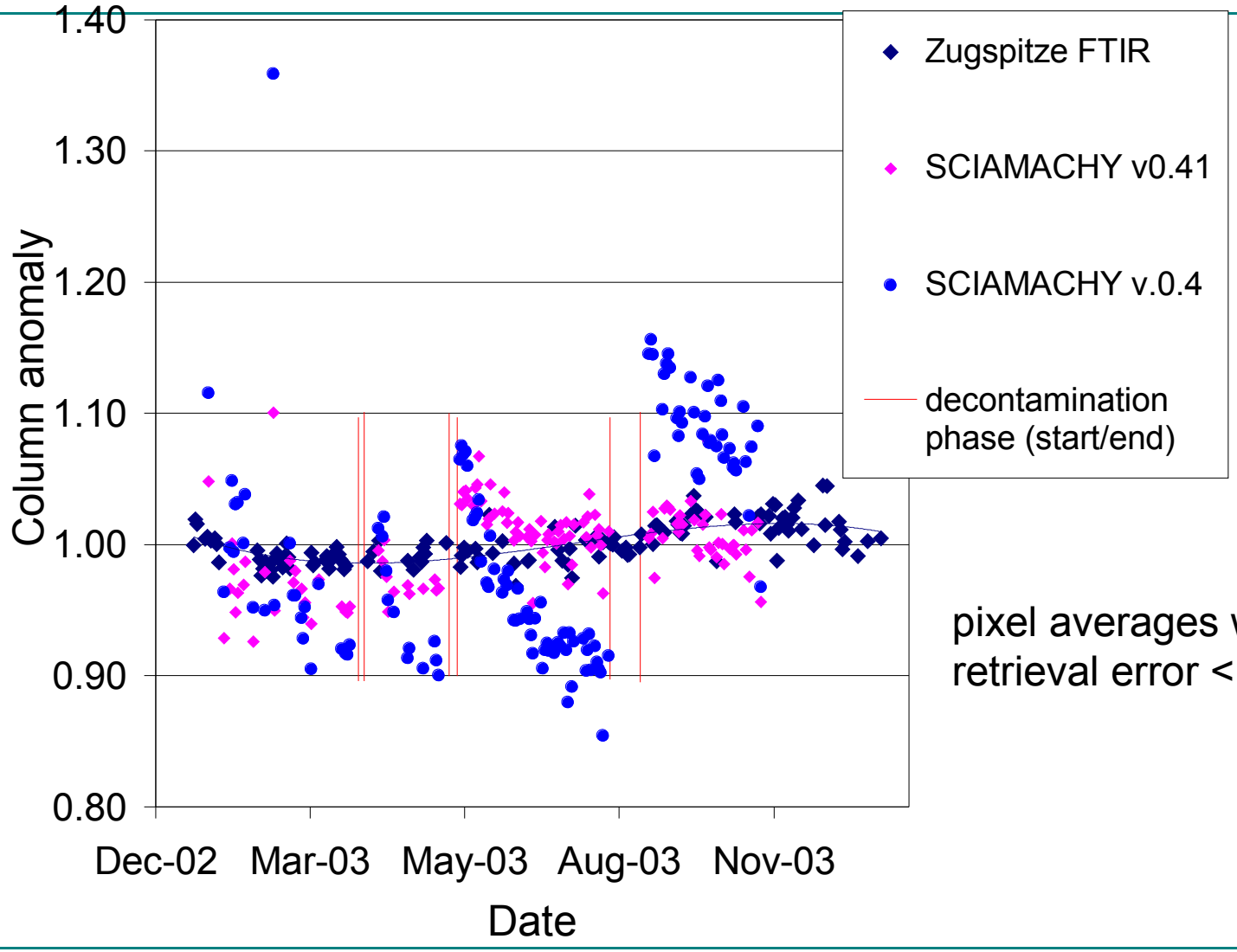
CH_4 Operational NRT Prod. Versions – July-2003: FTIR versus SCIA BIAS2 (NIR)

FTIR: Individual measurements (15-min integr.)

SCIA: Daily average of all pixels within 500-km radius



XCH_4 WFMD Product: FTIR versus WFMD v0.4 and WFMD v0.41



pixel averages within 2000 km;
retrieval error < 10 %

SCIAMACHY Validation by Zugspitze FTIR: CONCLUSIONS AS TO 7-DEC-2004

1. Operational total ozone (Master Set plus Reprocessing) shows good pixel-to-pixel reproducabilitiy and a realistic day-to-day scatter (pixel average within 500 km) – comparable to the ground FTIR. Column scaling factor: Zugspitze FTIR = SCIA * 0.95(±0.01).
2. Operational total NO_2 (Master Set plus Reprocessing) shows serious difficulties in monitoring the annual cycle (fall-winter decrease) above Zugspitze.
3. Scientific total NO_2 (UB 1.0, 1.5) perfectly monitors the annual cycle. It shows a realistic day-to-day scatter (200-km selection radius) after exclusion of pollution episodes. The column scaling factor (UB 1.5) is: Zugspitze FTIR = SCIA * 1.20(±0.02).
4. Scientific WFMD CO v0.4 shows a day-to-day scatter that is too high by a factor of 3.5 compared to the ground FTIR for a 1000-km selection radius. Higher selection radii are required to reflect the CO annual cycle in terms of a linear response. In the „September-2003 Release“ an unrealistic enhancement around Jul-2003 shows up. Column scaling factor is: FTIR = SCIA * 0.78(±0.06).
5. WFMD N_2O v0.4 day-to-day scatter is too high by a factor 10 even for averaging all pixels within a ±2000-km latitudinal band.
6. WFMD XCH_4 has shown a quality break-though from v0.4 to v.0.41 (time dependent correction, ice issue). However, systematic ice features still dominate over the day-to-day scatter for a 2000-km selection radius, thus masking the CH4 annual cycle.