

Validation of SCIAMACHY TOSOMI ozone columns with groundbased data (draft version)

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Abstract

TOSOMI is a scientific algorithm for retrieving ozone columns from SCIAMACHY spectra that was developed at KNMI. In this document, we present a comparison between one year of TOSOMI data and collocated groundbased measurements (94 instruments at 87 different geographical locations). TOSOMI ozone columns are, on average, 1.5% lower than the groundbased data, with a rms difference of 4.9% (all instruments) or 4.6% (Brewer and Dobson instruments). No clear dependence on geographical location exists.

Introduction

At KNMI, an algorithm aimed at deriving ozone column densities from Ozone Monitoring Instrument (OMI) measurements using the DOAS method was developed (Veefkind and De Haan, 2001). This algorithm has been applied to GOME data for creating scientific versions of the GOME ozone columns ("TOGOMI", Valks et al., 2003), and was recently also applied to SCIAMACHY NRT data ("TOSOMI"). TOSOMI-SCIAMACHY data are available within 3 hours after observation from <http://www.temis.nl/>. Currently, data are available starting from January 1, 2003.

This document presents a first validation of the TOSOMI ozone columns, using data for 2003. An IDL toolbox was developed for the purpose of intercomparing groundbased and satellite data over groundbased sites. Satellite data options are SCIAMACHY L2 (NRT & OL) and TOSOMI ozone columns, groundbased data options are all data in the Envisat NILU database and WOUDC total ozone data. Extension to other satellite data (OMI L2 ozone and NO₂ columns) is in progress.

Results

The TOSOMI 2003 ozone columns were compared to WOUDC daily averaged values of the ozone columns measured by Brewer and Dobson spectrophotometers (direct-sun as well as zenith included), and by Brewer, Dobson, DOAS, SAOZ and Filter measurements submitted to the Envisat NILU database. Figure 1 shows a map of used locations. Data present in the two databases on February 13, 2004 were included. Izaña DOAS data were multiplied by 1.092 to preliminary apply an airmass factor correction (M. Gil, 2004, personal communication).

For each of the instruments, timeseries were made of the data and the percent differences, along with TOSOMI - groundbased scatter plots. Yearly averaged bias and rms values for individual sites are presented in Figures 2 (as a function of latitude), 3, and 4 (on world maps), and tabulated along with correlation coefficients in the Appendix (Table A1). There, also examples are given of midlatitude, tropical, and polar comparisons.

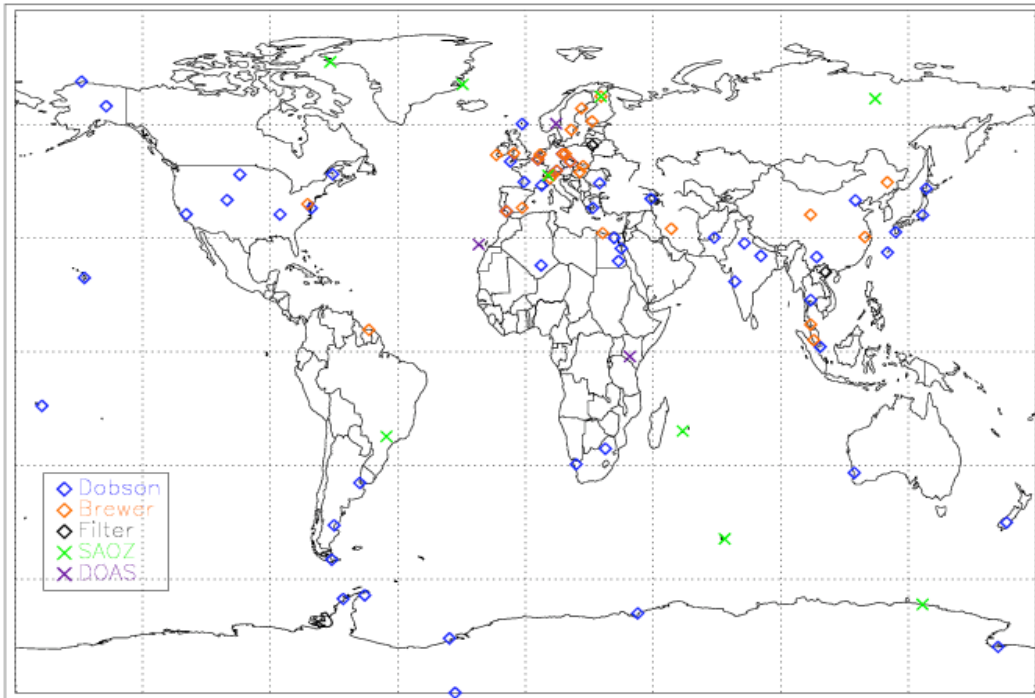


Figure 1: WOUDC or NILU stations with 2003 ozone column data.

The grand averages indicate that, with respect to groundbased data, TOSOMI data are offset by -1.5% with, averaged rms difference is 4.9%. The measurements by the Filter instrument at Hanoi were excluded from all averages, as they were clearly biased (20% bias, 20% rms, 10 measurements, similar results were reported from comparison to other satellites, cf. Bramstedt et al., 2002).

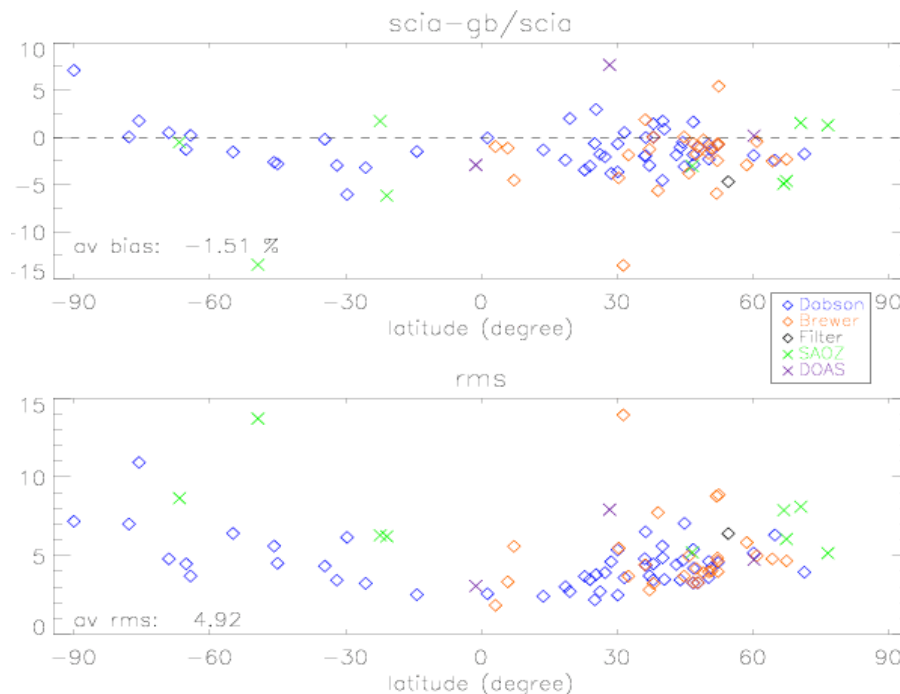


Figure 2: 2003 averages (top) and rms (bottom) of (SCIA-gb)/SCIA [%]

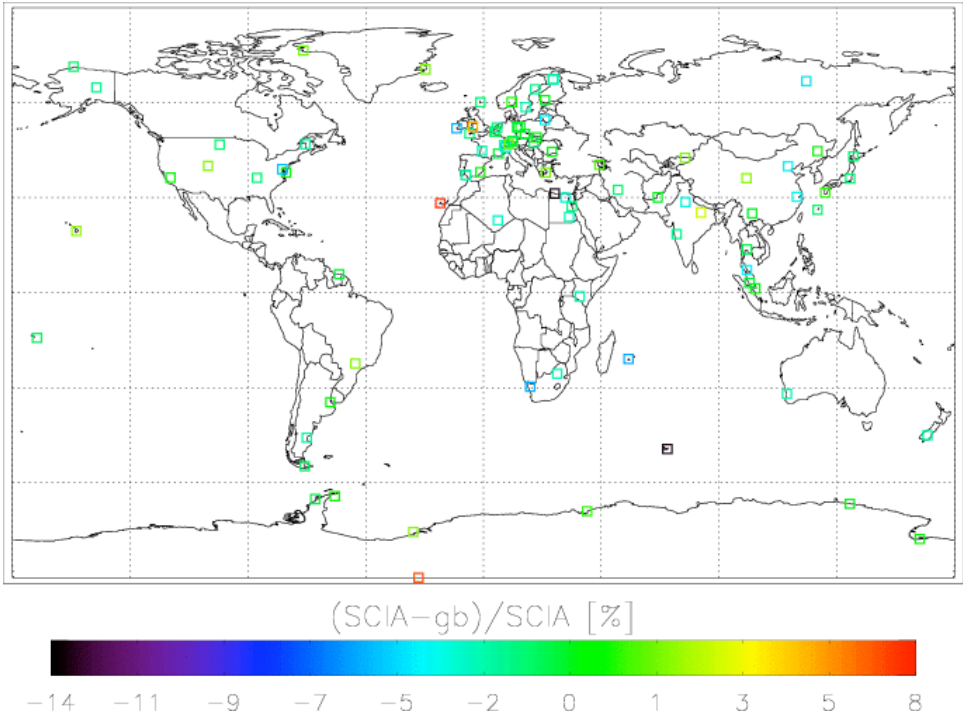


Figure 3: Overview of year-averaged differences (SCIA-groundbased)/SCIA [%]

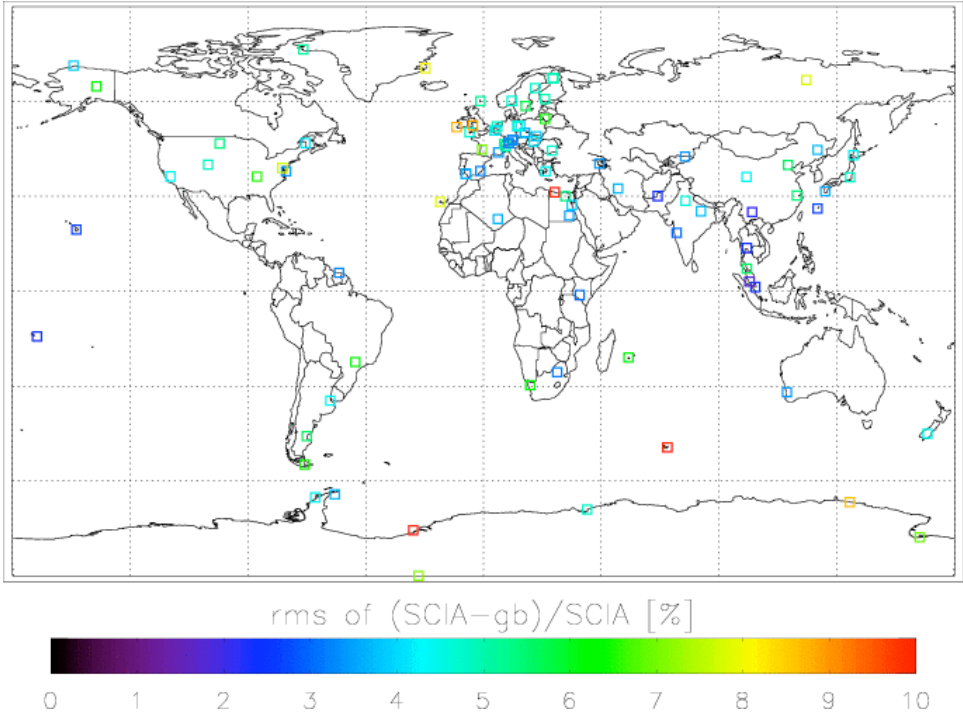


Figure 4: Overview of year-averaged rms of (SCIA-groundbased)/SCIA [%] – red squares denote 10% or more.

Averages were also made per latitude band (Table 2) and per instrument (Table 3). The Amundsen-Scott Dobson data were excluded from the SH polar region average, as they strongly influenced the small-number average (6 instruments) over that region.

If only Brewer and Dobson data are included in the comparisons, the grand averages do not change significantly (numbers are now offset=-1.4% and rms=4.6%). Also the averages per latitude band do not change much, except where few collocations are available (SH mid-latitudes and, to a lesser extent, NH tropics).

Table 1 – Latitude band averages (all instrument types)

LATITUDES	BIAS	RMS	#
All data	-1.5	4.9	93
Lat < -60 ¹	+0.1	6.6	6
-60 < lat < -30	-3.9	6.3	6
-30 < lat < 0	-3.0	4.6	6
0 < lat < 30 ²	-0.9	3.6	15
30 < lat < 60	-1.6	4.8	48
Lat > 60	-1.6	5.6	11

Table 2 – Latitude band averages (Brewer & Dobson only)

LATITUDES	BIAS	RMS	#
Total	-1.4	4.6	79
Lat < -60 ¹	+0.2	6.2	5
-60 < lat < -30	-2.0	4.9	5
-30 < lat < 0	-3.6	4.0	3
0 < lat < 30 ²	-1.5	3.3	14
30 < lat < 60	-1.6	4.8	45
Lat > 60	-1.9	5.0	6

Table 3– Results averaged per instrument type

INSTRUMENT	BIAS	RMS	#
Dobson	-1.2	4.4	52
Brewer	-2.0	5.0	27
SAOZ	-3.1	7.5	9
DOAS	+1.6	5.2	3
Other ²	-1.7	4.9	2

¹: Excluding Amundsen-Scott Dobson results

²: Excluding Hanoi Filter instrument results

Data dependences – plans for further studies

For Dobson and Brewer instruments, two measurement modes can be used – direct sun, which is more accurate but needs clear sky in the direction of the Sun for the duration of the integration, and zenith sky, which is less accurate. In the NILU database, it is not always clear whether data are direct-sun only, or a combination of direct-sun and zenith sky. When this is indicated, we always opt to use direct-sun results only. We have not yet investigated the effect of this choice on the validation outcome. In the WOUDC database,

the distinction is consistently made. So far, we have only investigated the direct-sun vs. zenith dependence by comparing individual station WOUDC validations presented earlier in this document with the same results for direct-sun measurements only. They were not significantly different, but the remark should be made that relatively few data were zenith-sky, many stations by default only report direct-sun measurements. We are planning to investigate this dependence further.

Also we expect a dependence on solar zenith angle (inducing a seasonal variation) which may also lead to large errors for polar winter. During polar winter, DOAS and SAOZ instruments are expected to yield data comparable in accuracy with those from other seasons (see, e.g., Lambert et al., 1999). Preliminary comparisons of validation results per site for different solar zenith angles do not yield a clear sza dependence. It may be that one year of data (and often less) is not enough to resolve such dependencies. This will be investigated further.

Preliminary comparisons of the validation results for various cloud fractions show that TOSOMI data become positively biased for cloud fractions above 0.9. For lower cloud fractions, no clear effects are seen. Again, statistics are poor due to limited data availability.

Acknowledgement

I acknowledge the use of groundbased ozone column data from the WOUDC and ENVISAT Validation databases. Tosomi-SCIAMACHY data were provided by Ronald van der A and Henk Eskes (KNMI).

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Please send comments on this document and suggestions for further validation to Ellen Brinksma, KNMI, brinksma@knmi.nl.

References

Lambert, J.-C., et al., *Investigation of Pole-to-Pole Performances of Spaceborne Atmospheric Chemistry Sensors with the NDSC*, J. Atm. Sci., 56, 1999.

Valks, P., J. P. Veefkind, J. F. de Haan, and R. van Oss, *TOGOMI Algorithm Theoretical Baseline Document*, TOGOMI/KNMI/ATBD/001, Issue 1.2, 01/11/2003.

Veefkind, J. P., and J. F. de Haan, *Chapter 3 – DOAS Total O3 Algorithm*, in OMI Algorithm Theoretical Basis Document, Volume II: OMI Ozone Products, ATBD-OMI-02, P. K. Bhartia (editor), 2002.

Appendix: Individual comparison results.

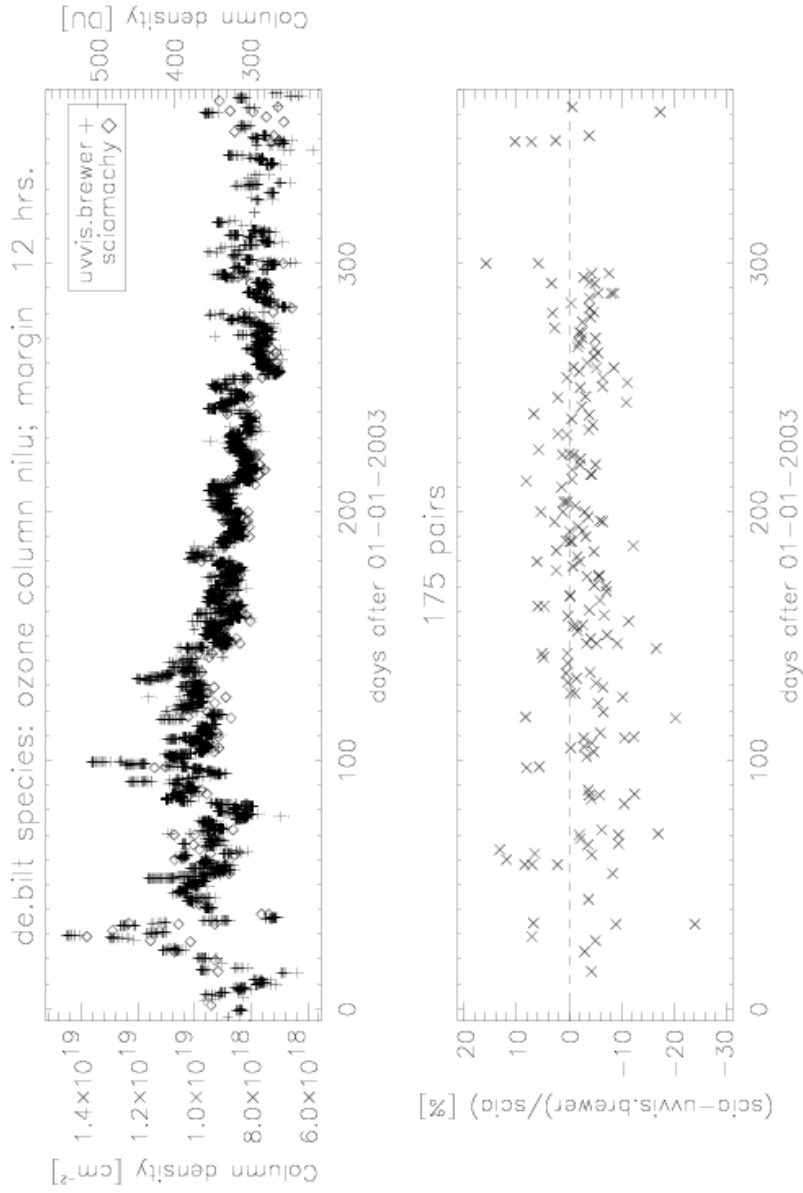
LOCATION	INSTR		LAT	LON	BIAS	RMS	CORR	#
amundsen scott	Dob	W	-89.98	-24.80	7.1	7.18	0.82	20
arrival heights	Dob	W	-77.83	166.67	0.05	7.01	0.92	31
halley bay	Dob	N	-75.6	-26.8	1.75	10.92	-0.570	31
Syowa	Dob	W	-69.0	39.58	0.49	4.79	0.970	133
dumont d'urville	SAO	N	-66.67	140.02	-0.52	8.65	0.740	65
Vernadsky	Dob	N	-65.2	-64.3	-1.29	4.47	0.760	38
Marambio	Dob	W	-64.23	-56.72	0.20	3.70	0.860	30
Ushuaia	Dob	W	-54.85	-68.31	-1.55	6.41	0.830	132
Kerguelen	SAO	N	-49.35	70.26	-13.49	13.71	0.830	114
comodoro rivadavia	Dob	W	-45.78	-67.5	-2.64	5.60	0.800	132
Lauder	Dob	W	-45.03	169.68	-2.82	4.51	0.750	43
buenos aires	Dob	W	-34.58	-58.48	-0.21	4.33	0.770	110
Perth	Dob	W	-31.92	115.95	-2.97	3.43	0.840	57
Springbok	Dob	W	-29.67	17.9	-6.06	6.16	0.770	60
Irene	Dob	W	-25.56	28.19	-3.21	3.23	0.800	45
Bauru	SAO	N	-22.35	-49.03	1.72	6.29	0.300	104
la reunion	SAO	N	-20.9	55.48	-6.19	6.22	0.650	161
Samoa	Dob	W	-14.25	-170.56	-1.50	2.51	0.570	38
Nairobi	DOA	N	-1.23	36.82	-2.93	3.06	0.710	179
Singapore	Dob	W	1.33	103.880	-0.06	2.57	0.690	99
petaling jaya	Bre	W	3.10	101.650	-0.97	1.84	0.730	98
Paramaribo	Bre	N	5.81	-55.21	-1.14	3.33	0.700	113
Songkhla	Bre	W	7.20	100.6	-4.55	5.59	0.810	11
Bangkok	Dob	W	13.67	100.61	-1.33	2.41	0.92	61
Poona	Dob	W	18.53	73.85	-2.41	3.02	0.88	61
mauna loa	Dob	W	19.53	-155.57	2.00	2.71	0.75	29
Hanoi	Fil	W	21.03	105.85	-20.1	20.1	0.06	10
Tamanrasset	Dob	W	22.8	5.52	-3.46	3.68	0.83	177
Aswan	Dob	W	23.97	32.78	-3.05	3.47	0.87	165
Kunming	Dob	W	25.03	102.68	-0.65	2.18	0.92	57
Varanasi	Dob	W	25.32	83.03	2.96	3.79	0.66	86
Naha	Dob	W	26.2	127.68	-1.80	2.71	0.92	130
Hurghada	Dob	W	27.28	33.75	-2.07	3.91	0.68	188
Izaña	DOA	N	28.31	-16.5	7.67	7.92	0.62	56
new delhi	Dob	W	28.65	77.22	-3.83	4.61	0.76	133
Cairo	Dob	W	30.08	31.28	-3.66	5.36	0.72	196
Quetta	Dob	W	30.11	66.57	-0.69	2.49	0.71	86
Linan	Bre	W	30.3	119.73	-4.30	5.47	0.76	92
marsa matrouh	Bre	W	31.33	27.22	-13.57	13.94	0.77	193

LOCATION	INSTR		LAT	LON	BIAS	RMS	CORR	#
Kagoshima	Dob	W	31.58	130.57	0.52	3.59	0.81	129
Isfahan	Bre	W	32.48	51.42	-1.87	3.69	0.77	49
Tsukuba	Dob	W	36.06	140.1	-1.99	4.80	0.86	138
mt waliguan	Bre	W	36.17	100.530	1.87	4.42	0.85	116
Nashville	Dob	W	36.25	-86.57	-1.93	6.51	0.44	44
Hanford	Dob	W	36.32	-119.63	-0.02	4.37	0.84	59
el arenosillo	Bre	W	37.1	-6.73	-1.27	2.81	0.89	107
el arenosillo	Dob	W	37.1	-6.73	-2.98	3.72	0.79	30
wallops island	Dob	W	37.93	-75.48	0.04	3.44	0.81	29
Athens	Dob	W	37.98	23.73	1.43	4.47	0.94	11
Murcia	Bre	W	38.0	-1.17	0.02	3.23	0.86	64
Goddard	Bre	W	38.99	-76.83	-5.65	7.73	0.59	56
Xianghe	Dob	W	39.97	116.37	-4.56	5.60	0.86	104
Boulder	Dob	W	40.03	-105.25	1.72	4.85	0.84	48
Amberd	Dob	W	40.38	44.25	0.870	3.48	0.90	114
issyk.kul	?	W	42.62	76.98	1.47	3.39	0.92	112
Sapporo	Dob	W	43.06	141.33	-1.86	4.43	0.91	146
haute provence	Dob	W	43.93	5.70	-1.08	3.45	0.85	79
Bucharest	Dob	W	44.48	26.13	-0.530	4.69	0.85	139
Longfengshan	Bre	W	44.75	127.6	0.05	3.70	0.93	105
Bordeaux	Dob	W	44.84	-0.530	-3.10	7.05	0.62	33
j.r.c.ispra varese	Bre	W	45.8	8.63	-3.80	4.98	0.89	182
Jungfrauoch	SAO	N	46.55	7.98	-3.04	5.21	0.84	177
Bismarck	Dob	W	46.77	-100.75	-1.85	5.39	0.80	68
Arosa	Bre	W	46.78	9.68	-0.64	3.29	0.90	172
Arosa	Dob	W	46.78	9.68	1.63	3.25	0.90	159
Caribou	Dob	W	46.87	-68.03	-2.87	4.19	0.51	5
budapest lorinc	Bre	W	47.43	19.18	-1.78	4.18	0.89	151
Hohenpeissenberg	Bre	W	47.8	11.02	-0.99	3.27	0.89	170
Hohenpeissenberg	Dob	W	47.8	11.02	-1.07	3.27	0.90	125
poprad-ganovce	Bre	W	49.03	20.32	-0.270	3.91	0.88	231
hradec kralove	Bre	W	50.18	15.83	-1.68	3.97	0.89	210
hradec kralove	Dob	W	50.18	15.83	-0.73	3.60	0.86	175
camborne	Dob	W	50.22	-5.32	-2.32	4.63	0.89	142
uccele	Bre	W	50.8	4.35	-1.13	4.01	0.88	174
uccele	Dob	W	50.8	4.35	-1.38	4.22	0.88	127
valentia	Bre	W	51.93	-10.25	-5.95	8.78	0.20	26
de bilt	Bre	N	52.1	5.18	-2.47	4.85	0.89	175
lindenberg	Bre	W	52.21	14.12	-0.81	3.98	0.89	196
potsdam	Bre	W	52.22	13.05	-0.66	4.67	0.84	54
potsdam	Dob	W	52.22	13.05	-0.75	4.55	0.89	46
aberystwyth	Bre	N	52.42	-4.05	5.41	8.87	0.51	70

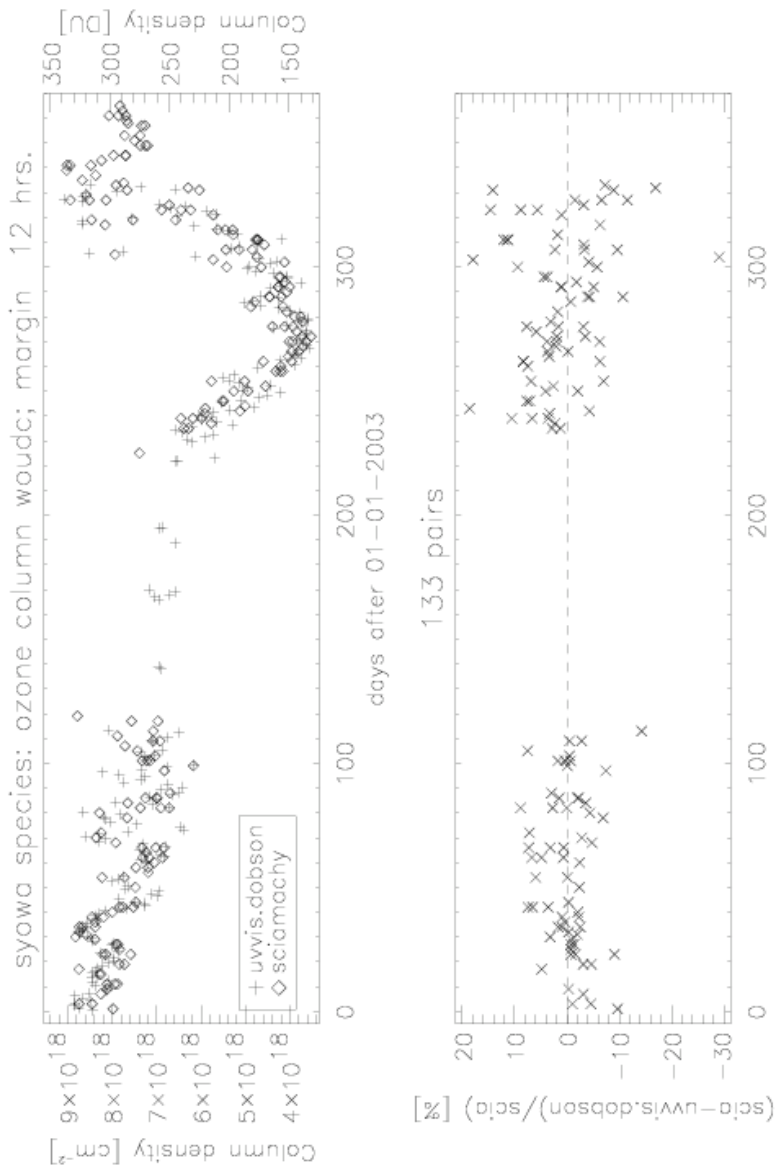
LOCATION	INSTR		LAT	LON	BIAS	RMS	CORR	#
kaunas	Fil	W	54.52	23.54	-4.70	6.40	0.86	200
norrkoeping	Bre	W	58.58	16.15	-2.93	5.83	0.87	210
lerwick	Dob	W	60.13	-1.18	-1.91	5.16	0.91	116
harestua	DOA	N	60.2	10.8	0.17	4.73	0.88	179
jokioinen	Bre	N	60.82	23.5	-0.46	4.99	0.86	188
vindeln	Bre	W	64.24	19.77	-2.52	4.79	0.90	157
fairbanks	Dob	W	64.82	-147.87	-2.42	6.31	0.06	14
zhigansk	SAO	N	66.79	123.35	-4.94	7.88	0.89	119
sodankyla	SAO	N	67.37	26.63	-4.62	6.05	0.90	171
sodankyla	Bre	N	67.37	26.63	-2.33	4.66	0.91	174
scoresbysund	SAO	N	70.53	-22.17	1.52	8.11	0.72	121
barrow	Dob	W	71.32	-156.6	-1.76	3.94	0.96	45
thule	SAO	N	76.5	-68.8	1.28	5.15	0.94	69

Timeseries examples for individual stations

Midlatitude result: De Bilt Brewer

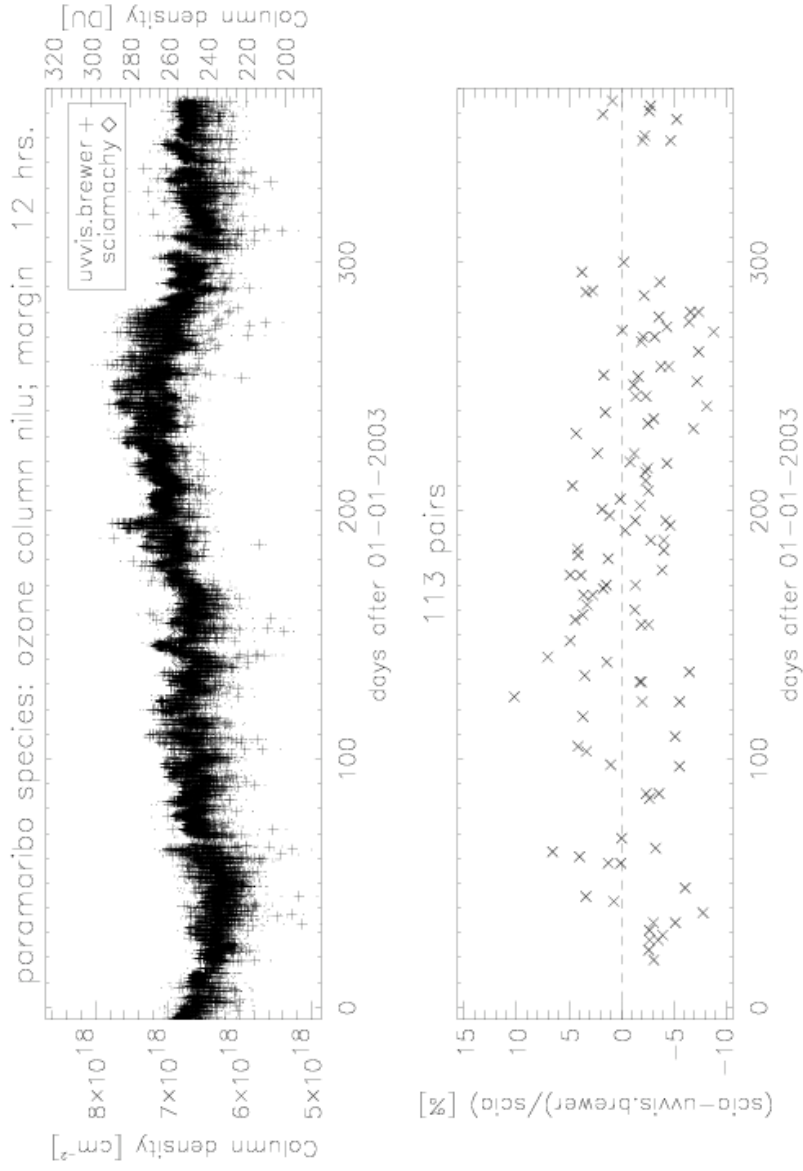


Antarctic result: Syowa Dobson



mean diff: 0.49%, rms: 4.79% station lat/lon: -69.00 39.58

Tropical result: Paramaribo Brewer



mean diff: -1.14%, rms: 3.33% station lat/lon: 5.81 -55.21