TOTAL OZONE MEASUREMENTS AT ITALIAN BREWER STATIONS (ROME AND AOSTA)

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INTRODUCTION The availability of long-term records of total ozone content (TOC) and UV data represents a valuable source of information in studies on the assessment of short and long-term changes and their impact on terrestrial ecosystem. In addition, ground-based observations provide the ground-truth for satellite-derived products, mainly in polluted and in mountain areas where large uncertainties in space-borne estimates may be detected. To our knowledge, details about processing software packages applied to Brewer TOC measurements are usually not specified in studies on satellite vs ground-based comparisons and on the long term TOC variability. This study analyzes the differences between TOC data processed by the Brewer Processing Software (BPS, by Dr Fioletov and Ogyu of Environment Canada) and by O3Brewer (by Dr Stanek of Solar and Ozone Observatory of CHMI/International Ozone Service). The comparison of BPS and O3Brewer data with Ozone Monitoring Instrument (OMI).

GROUND-BASED DATA (GB)

Aosta (Brewer #066, 45.7°N, 7.4°E, 570 m asl): 29/01/2007-31/12/2015

Rome (Brewer #067, 41.9°N, 12.5°E, 75 m asl): 01/01/1992-31/12/2015

SATELLITE DATA (SAT)

Aura OMI OMTO3(v8.5, L2 OVP): 01/10/2004-31/12/2015

(source: http://avdc.gsfc.nasa.gov)

STATISTICAL METRICS USED IN THE COMPARISON

A measure of the agreement is given by the following parameters: Spearman correlation (RHO), Mean Percentage Error (MPE%), Mean Bias (MB) Standard Deviation from MB, Root Mean Square Error (RMSE) and their normalized (%) values with respect to the TOC ground-based means.

BREWER DS PROCESSING ALGORITHM

Direct Sun TOC calculation DS= (MS(9)-ETC+(XR6-R6))/(Δα ·mu)

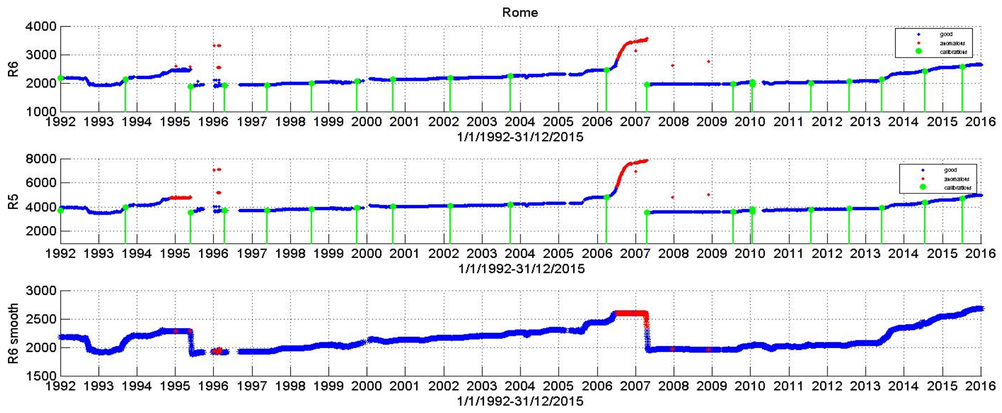
MS(9)= double ratio; ETC= extra terrestrial constant; XR6 = value of R6 from the last calibration; R6= R6 ratio for the day; Δα = weighted ozone absorption coefficient, mu = air mass.

DS measurements were processed with the rejection criteria: measurement Max_DS_std = 2.5 DU (std=standard deviation), Max_mu = 4.0 in both software packages.

Standard lamp (SL) correction:

BPS adjusts the ETC based on the difference between SL test values at the time of the most recent calibration and the present values. It takes the average of SL-test values from 15 consecutive days since that calibration.

O3Brewer adjusts the ETC using a smoothing filter (Gaussian, 20-days width) on SL ratios creating the SLsmooth file.



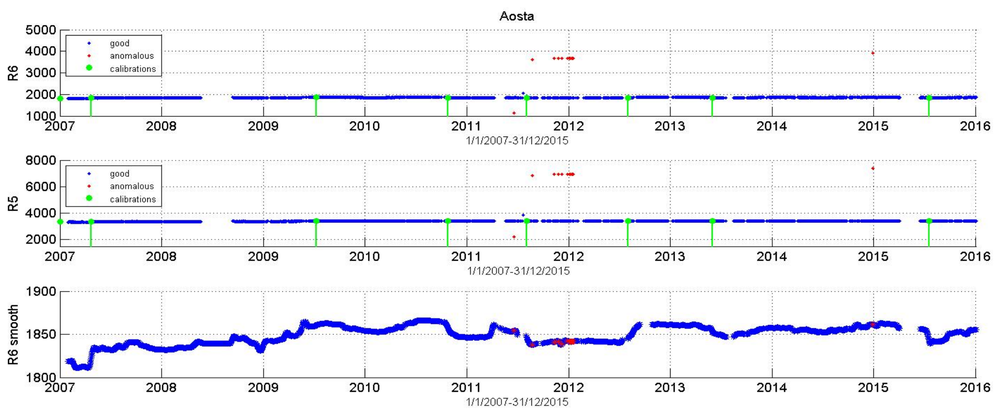
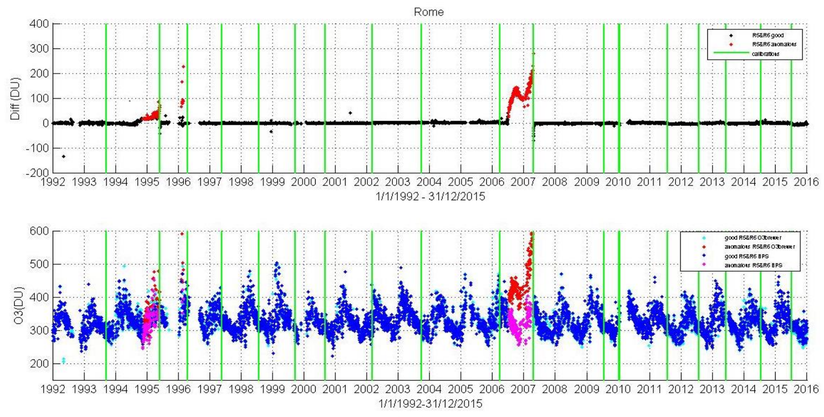


Fig. 1: Daily R6 and R5 time series and R6 smoothed (from SLsmooth file created by O3Brewer software). SL correction is not applied by O3brewer when there are no SL measurements and when R6 and R5 values are above 400 units and 700 units, respectively in reference to the values of the last calibration. These are indicated as anomalous R5 and R6 values (red dots). Days without both R5 and R6 values are not considered.



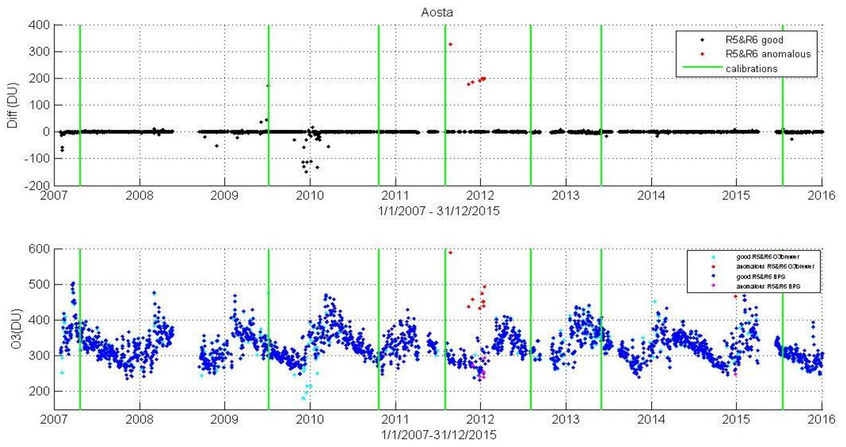
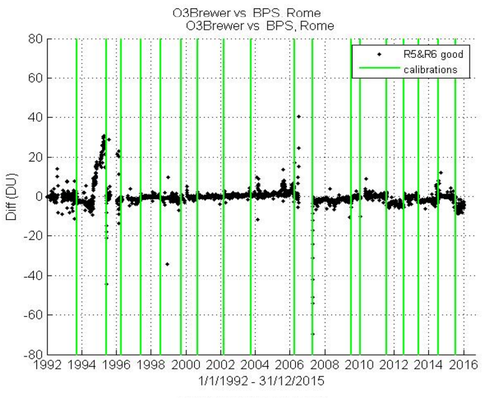


Fig. 2: Differences (1st and 3rd panel) in daily TOC values between O3Brewer and BPS. The time series of TOC daily means processed with BPS and O3Brewer (2nd and 4th panel).



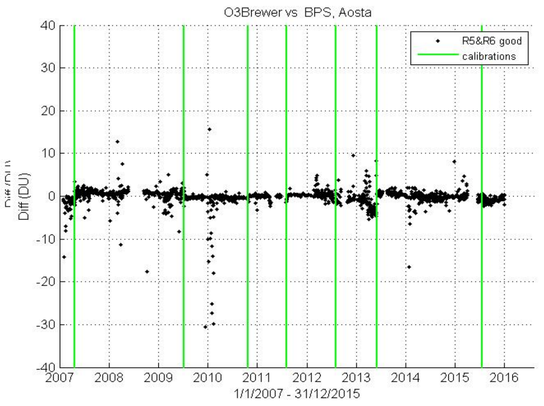


Fig. 3: Differences in TOC daily means between O3Brewer and BPS for good R6 and R5 values. TOC data with daily std>50 DU and without SL measurements, are excluded. Large differences (~10%) still persist between the two processed TOCs.

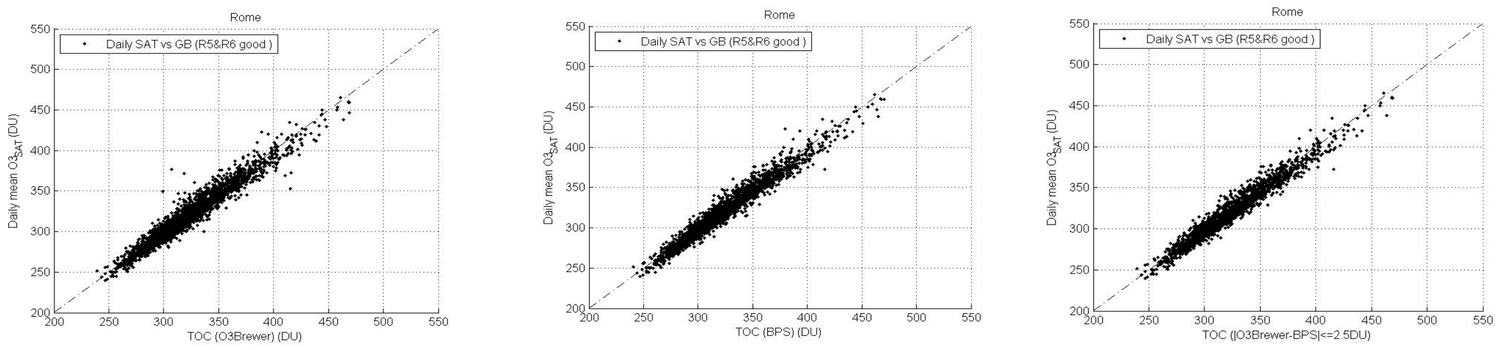


Fig. 3: Scatter plots OMI vs ground- based TOC (O3Brewer, on left panel; BPS on the central panel, on the right when |O3brewer-BPS| ≤2.5) for R6 & R5 good and std ≤50 DU.

O3Brewer_vs_BPS	n	RHO	MPE (%)	MBE DU (%)	RMSE DU (%)
Rome					
All data	6453	0.919	1.15	3.60 (1.17)	21.34 (6.53)
Data with good R5 &R6	5994	0.994	-0.18	-0.56 (-0.17)	3.64 (1.11)
Aosta					
All data	2315	0.982	0.20	0.47 (0.14)	11.09 (3.39)
Data with good R5 &R6	2162	0.999	-0.04	-0.16 (-0.05)	2.02 (0.62)

Table 1: Summary of the statistics O3Brewer vs BPS (n= number of pairwise measurements). Data with std >50 DU per day and without SL measurements, are excluded. In brackets the normalized values are in percentages (%) .

OMI_vs_GB (good R5 & R6)	n	RHO	MPE (%)	MBE DU (%)	Stand.dev. from MBE DU (%)	RMSE DU (%)
Rome						
daily std ≤50 DU						
O3Brewer	2452	0.964	-0.76	-2.56 (-0.80)	8.49 (2.64)	8.87(2.75)
BPS	2449	0.978	-1.14	-3.73 (-1.15)	7.26 (2.25)	8.16 (2.52)
daily std ≤2.5 DU						
O3Brewer	693	0.976	-1.16	-3.62 (-1.17)	6.65 (2.15)	7.57 (2.45)
BPS	692	0.980	-1.52	-4.71 (-1.52)	5.95 (1.92)	7.58 (2.45)
daily std ≤ 50 DU						
O3Brewe-BPS ≤ 2.5 DU	1830	0.975	-0.93	-3.11 (-0.96)	7.64 (2.37)	8.25 (2.55)
daily std ≤ 2.5DU						
O3Brewe-BPS ≤ 2.5 DU	540	0.976	-1.30	-4.07 (-1.31)	6.38 (2.06)	7.56 (2.44)
Aosta						
daily std ≤50DU						
O3Brewer	1816	0.983	-2.37	-7.76 (-2.36)	7.23 (2.20)	10.60 (3.23)
BPS	1815	0.984	-2.41	-7.89 (-2.40)	6.98 (2.13)	10.53 (3.21)
daily std ≤2.5DU						
O3Brewer	529	0.984	-2.40	-7.28 (-2.37)	6.08 (1.98)	9.48 (3.09)
BPS	528	0.985	-2.39	-7.25 (-2.36)	5.92 (1.93)	9.36 (3.05)
daily std ≤50 DU						
O3Brewer-BPS ≤ 2.5 DU	1718	0.984	-2.44	-7.92 (-2.43)	6.82 (2.09)	10.45 (3.20)
daily std ≤2.5 DU						
O3Brewer-BPS ≤ 2.5 DU	527	0.984	-2.39	-7.27 (-2.37)	6.09 (1.98)	9.48 (3.09)

Table 2: Summary of the statistics OMI vs ground based TOC (O3Brewer and BPS). TOC were selected with std ≤50 DU and std ≤2.5DU per day (good R5 and R6 values). The comparison was also made with |O3brewer-BPS| ≤2.5 DU. In brackets the normalized values in % .

CONCLUSIONS This study analyzed the difference between total ozone column processed by two different software packages in Rome and Aosta. When anomalous SL values occurr, the smoothing filter correction in O3Brewer is not applied, producing TOC anomalies. The difference between BPS and O3Brewer can be less than 1% when R5 and R6 differ by about 20% with respect to the values of the last calibration. However, large differences (up to ~10%) can be still observed, probably due to the larger SL correction applied by BPS with respect to the smoothed correction of O3Brewer. In both sites, the comparison between OMI and ground-based data (taking into account data with good R5 and R6 values) shows a a systematic underestimation of satellite TOC, although some differences between the two processing software packges were found (sligthly higher if TOC data are processed with BPS). This result suggests that a standardized processing protocol (COST Action ES1207-EUBREWNET) is necessary to avoid the inconsistency in SL correction application between different Brewer data processing software packages. Alternately, users could use more than one package as a cross validation of own data.