CONSISTENCY IN THE VARIATIONS OF TOTAL COLUMN OZONE INFERRED FROM OMI AND SBUV-2 DURING 2004-2007

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Abstract

Detailed studies have been conducted to investigate the variability of total column ozone using the monthly zonal mean measurements from OMI (TOMSv8) and NOAA-16 SBUV-2 satellite data sets for the overlap period of October 2004 through March 2007. The monthly zonal means derived from the two data sets generally agree to within 3 to 4 DU with the exception of March-April periods near 40N-45N where the discrepancies could reach 7 to 8 DU. In terms of percentage, the agreements are always within 2%. Changes between two consecutive years at 24 latitudinal zones (60S-55S,......., 55N-60N) were derived from the differences in monthly zonal means for eighteen pairs of months (Oct-04 vs Oct-05; Nov-04 vs Nov-05; ..... Mar-06 vs Mar-07). Our analysis revealed that the year-to-year changes inferred from OMI and SBUV-2 measurements show very good agreement, generally within 1 DU, indicating that the relative biases for the same calendar month and the same latitudinal zone do not change with time throughout the 30-month period.

I. INTRODUCTION

Concern for changes in the ozone layer due to human activity is an important subject for the scientific community. Accurate long-term data records of total column ozone are required for the scientific assessment of ozone depletion [WMO, 2006].

The objective of this study is to conduct an investigation of the variability of total column ozone using the monthly zonal mean measurements from OMI(TOMSv8) and NOAA-16 SBUV-2 for the overlap period of October 2004 through March 2007. Discussions will be focused on the consistency of the year-to-year changes in total column ozone inferred from these two independent multi-year satellite measurements.

II. OVERVIEW OF AURA/OMI AND NOAA-16 SBUV/2

The Ozone Monitoring Instrument (OMI) is a nadir-viewing near-UV/Visible CCD spectrometer aboard NASA's Earth Observing System's (EOS) Aura satellite [Schoeberl et al., 2006]. Aura was launched on July 15, 2004, and OMI began to produce data in October 2004. OMI measurements cover a spectral region of 270-500 nm with a spectral resolution between 0.42 nm and 0.63 nm and a nominal ground footprint of 13X24 km^2 at nadir [Levelt et al., 2006]. Global coverage is achieved on a daily basis.

Two algorithms are available for the total column ozone retrieval: enhanced TOMS Version 8 (TOMSv8) algorithm and the Differential Optical Absorption Spectroscopy (DOAS) technique. Validation studies of the corresponding data products have been reported recently [Balis et al., 2007; McPeters et al., 2007]. The results discussed in this study are based on the OMI TOMSv8 total column ozone data products.

The Merged Ozone Data Set (MOD) uses measurements from six satellites: Nimbus 7 TOMS, Nimbus 7 SBUV, NOAA 9, 11, and 16 SBUV/2s, and Earth Probe TOMS. The data released by the individual instrument teams are used and additional adjustments to each record were applied such that the merged data set is calibrated relative to a reference standard [Stolarski et al., 2006]. The term "SBUV/2" used throughout this paper referred to the NOAA-16 SBUV/2 data record that is incorporated into the MOD. It is essentially the NOAA-16 SBUV/2 profile total ozone with an adjustment of -1.1 DU applied to all latitudes.

III. EXTRACTION OF MONTHLY ZONAL MEANS

For the 30-month period covering October 2004 through March 2007, monthly zonal mean total column ozone were derived for 5-degree latitudinal zones (60S-55S, 55S-50S, ... 50N-55N, 55N-60N) using both OMI(TOMSv8) and NOAA-16 SBUV/2 level-2 data products. Year-to-year changes were extracted from the two data sets by computing the differences of monthly zonal means for the (18) pairs of months which are one year apart (e.g. OCT 2005 minus OCT 2004, NOV 2005 minus NOV 2004, ... MAR 2007 minus MAR 2006).

IV. RESULTS AND DISCUSSIONS

Intercomparisons of monthly zonal mean total column ozone from OMI and SBUV/2 are depicted in Figure (1) using examples from November 2004 and March 2007. The consistency of the two data sets regarding the latitudinal variability is revealed in Fig. 1(a). Additional information of the differences (OMI minus SBUV/2) are shown in Fig.1(b) and Fig.1(c) in terms of Dobson Unit (DU) and percentage respectively.

More detailed characteristics of the differences in monthly zonal mean total ozone are shown in Figure (2) for the entire 30-month period (October 2004 - March 2007) and for six selected latitudinal zones. The results in Fig.2(a) indicate that OMI and SBUV/2 measurements of monthly zonal mean total ozone generally agree to within 3-4 DU with the exception of March-April periods where larger differences (7 to 8 DU) appear in the latitudes 40N-45N. It is worth noticing that the differences in percentage are always within 2% as seen in Fig. 2(b).

Figure (3) illustrates the year-to-year changes in total column ozone based on the changes from December 2004 to December 2005 and from June 2005 to June 2006. OMI and SBUV/2 exhibit remarkably good agreement regarding the latitudinal patterns and the magnitudes of the year-to-year changes in total column ozone. For December 2004 to December 2005, both data sets detect an increase of more than 10 DU near 45S-55S and a decrease of comparable magnitude near 15N-25N. Insignificant changes appear at 35N-40N and throughout 30S to 5N. For June 2005 to June 2006, increments of 18-19 DU were observed near the Equator (5S-5N) while very large decrease, with magnitudes exceeding 20 DU were detected at 30S-40S. Additional examples of year-to-year changes inferred from the two data sets are depicted in Figure (4) and Figure (5) for changes from February 2005 to February 2006 and from February 2006 to February 2007 respectively.

Values of year-to-year changes in total column ozone in Dobson units are listed in Table (1). The entries in columns 2, 3 and columns 5, 6 clearly demonstrate very good agreement for the changes from October 2004 to October 2005 and from February 2005 to February 2006 respectively. The two columns under the headings "(a) minus (b)" further revealed that the agreements are generally within 1 Dobson unit throughout all latitudinal zones. Examination of other tabulated results similar to Table (1) has led to the conclusion that this statement is generally valid for all (18) pairs of months that we have analyzed.

The results of comparisons in Figure 2(a) and Table (1) point to the fact that although the two satellite measurements are within 3 to 4 DU in terms of monthly zonal mean total ozone, the inferred year-to-year changes show much better agreement (within 1 DU). Additional evidence supporting these findings are listed in Table 2(a) and 2(b) using the examples from the latitudinal zones 35S-40S (October 2004, 2005, 2006) and 45N-50N (March 2005, 2006, and 2007). The entries in the last row of Table 2(a) clearly indicate that for the same calendar month and same latitudinal zone, the relative biases between OMI and SBUV/2 do not change from year to year, leading to the very close agreement (within 1 DU) in the year-to-year changes inferred from the two data sets.

V. CONCLUDING REMARKS

We have presented an investigation of the consistency in the variations of total column ozone using the monthly zonal mean measurements from OMI (TOMSv8) and NOAA-16 SBUV/2 satellite data sets covering October 2004 through March 2007. Our analysis revealed that the year-to-year changes inferred from the two data sets show very good agreement, generally within 1 DU, indicating that the relative biases for the same calendar month and the same latitudinal zone do not change with time throughout the 30-month period. Both OMI and NOAA-16 SBUV/2 are still in operation. Thus, further assessment of the consistency between the continued records of these two data sets will be needed. In addition, intercomparisons with global ozone measurements from other ongoing satellite instruments such as NOAA-17, 18 SBUV/2s and METOP GOME-2 will be conducted to enhance our understanding of the capabilities and limitations of various ozone monitoring satellite projects.

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Fig.1 Examples for Intercomparisons of Monthly Zonal Means

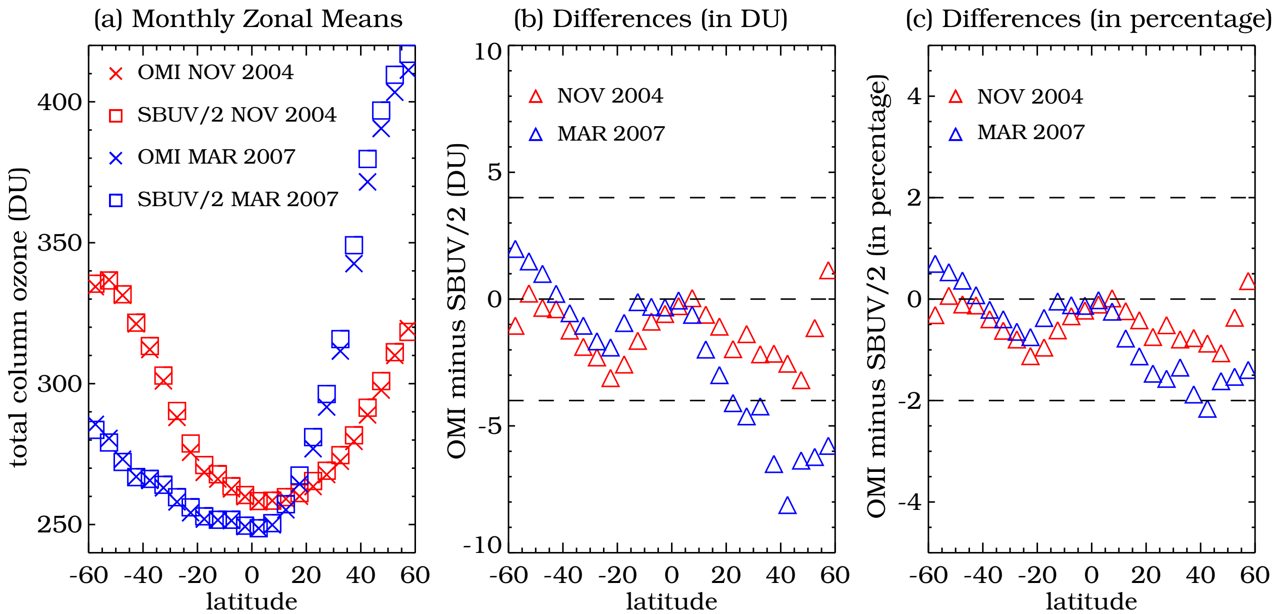

Fig.2 Comparisons for six selected latitudinal zones (OCT 2004 - MAR 2007)

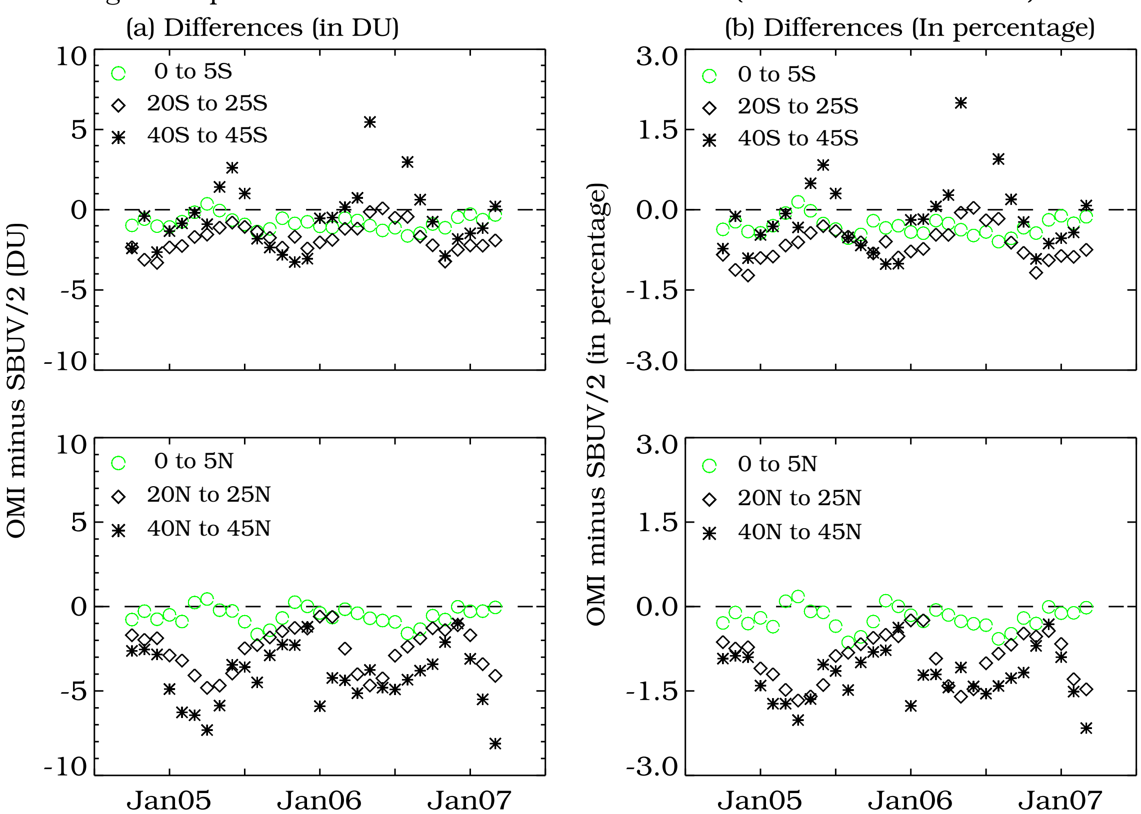

Fig. 3 Examples of Consistency in the yr-to-yr changes

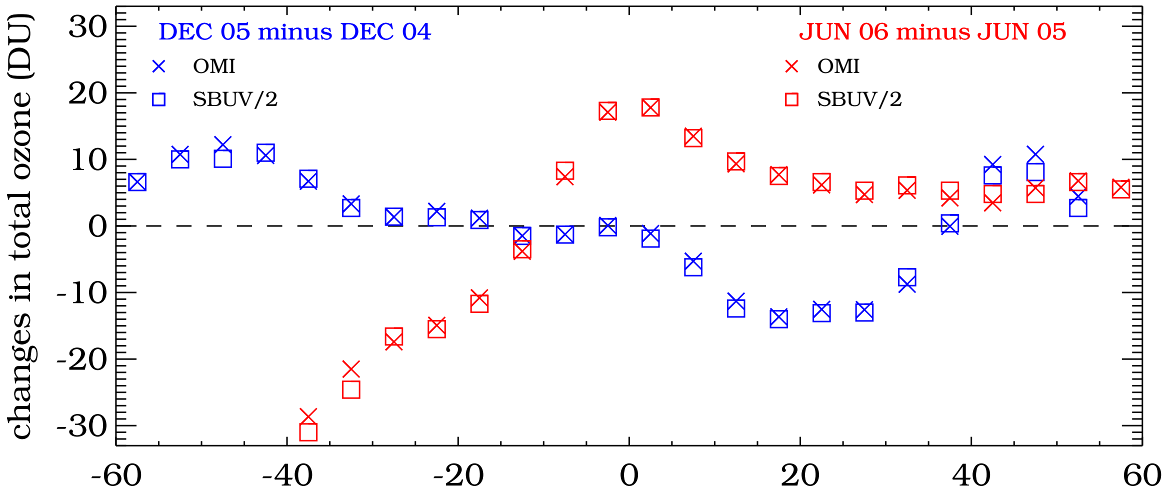

Fig. 4 February 2006 minus February 2005

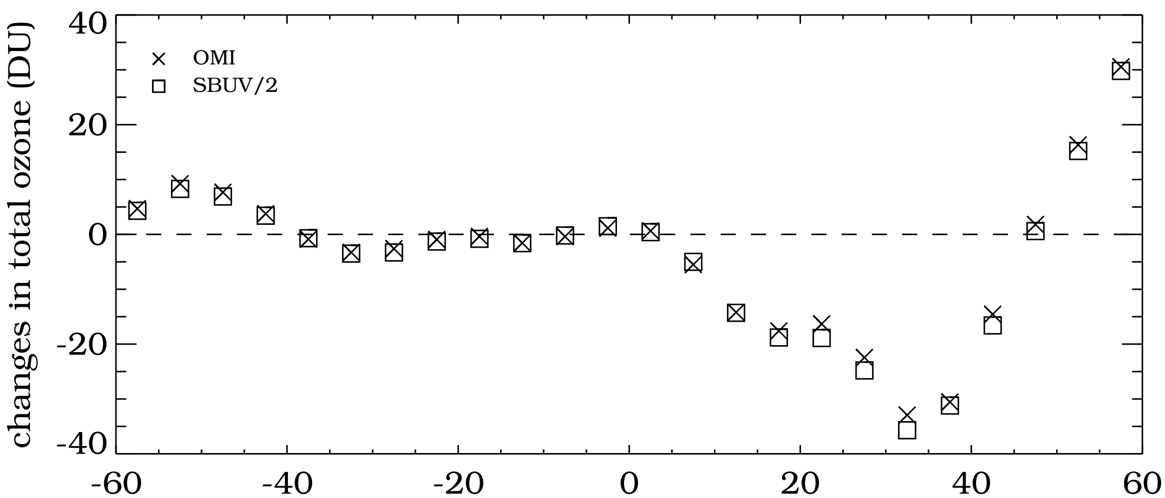

Fig.5 February 2007 minus February 2006

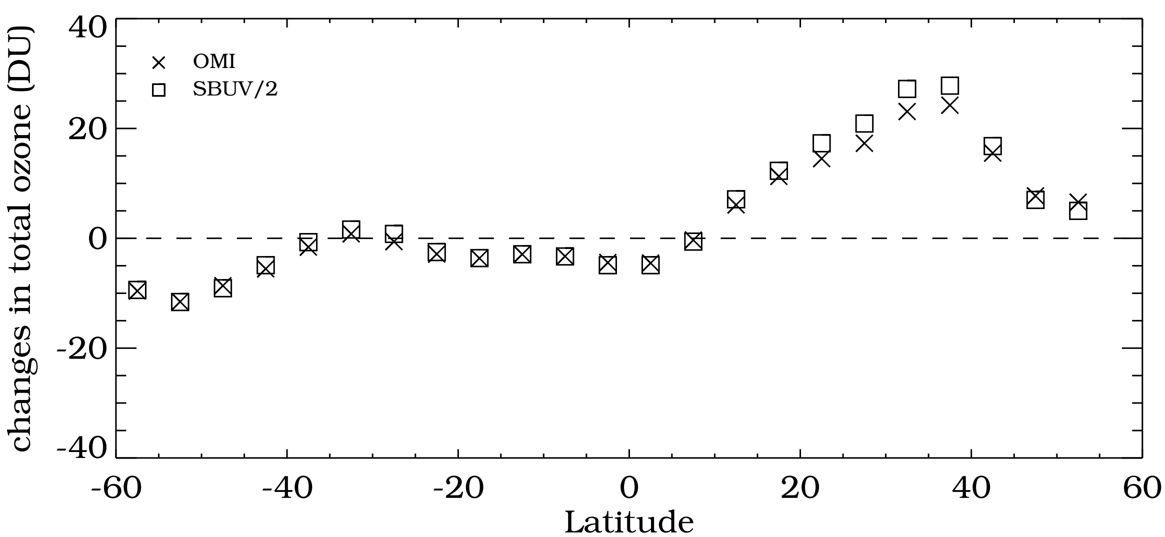

Table (1): Examples of Year-to-year changes in total column ozone

Latitude	OCT 05 minus OCT 04			FEB 06 minus FEB 05		
	Changes in O3(DU)		(a) minus (b)	Changes in O3(DU)		(a) minus (b)
	(a)OMI	(b)SBUV/2		(a)OMI	(b)SBUV/2	
60S to 55S	N/A	N/A	N/A	4.68	4.30	0.38
55S to 50S	9.11	9.10	0.01	9.25	8.30	0.95
50S to 45S	16.41	16.90	-0.49	7.68	6.90	0.78
45S to 40S	18.19	18.60	-0.41	3.76	3.40	0.36
40S to 35S	16.23	16.10	0.13	-0.87	-0.70	-0.17
35S to 30S	14.02	14.00	0.02	-3.29	-3.50	0.21
30S to 25S	13.07	14.10	-1.03	-2.61	-3.30	0.69
25S to 20S	11.38	11.40	-0.02	-0.92	-1.30	0.38
20S to 15S	8.14	7.80	0.34	-0.37	-0.80	0.43
15S to 10S	4.15	3.60	0.55	-1.57	-1.60	0.03
10S to 5S	-2.97	-3.30	0.33	-0.39	-0.20	-0.19
5S to 0	-8.35	-8.80	0.45	1.15	1.50	-0.35
0 to 5N	-10.60	-10.70	0.10	0.63	0.40	0.23
5N to 10N	-9.23	-9.20	-0.03	-5.50	-5.00	-0.50
10N to 15N	-6.06	-5.50	-0.56	-14.20	-14.30	0.10
15N to 20N	-3.85	-3.80	-0.05	-17.60	-18.80	1.20
20N to 25N	-4.47	-4.70	0.23	-16.31	-18.90	2.59
25N to 30N	-6.39	-6.40	0.01	-22.44	-24.80	2.36
30N to 35N	-8.71	-8.90	0.19	-32.93	-35.70	2.77
35N to 40N	-8.20	-7.70	-0.50	-30.56	-31.20	0.64
40N to 45N	-4.43	-4.80	0.37	-14.56	-16.60	2.04
45N to 50N	-0.18	-1.10	0.92	1.81	0.60	1.21
50N to 55N	1.05	1.90	-0.85	16.31	15.20	1.11
55N to 60N	-1.36	-1.80	0.44	30.55	29.80	0.75

Table 2(a): Examples of Consistency in Zonal Mean Total Ozone (in DU)

Data Set	35S-40S			45N-50N		
	OCT 2004	OCT 2005	OCT 2006	MAR 2005	MAR 2006	MAR 2007
(i) OMI	316.5	332.7	313.4	384.5	377.6	390.5
(ii)SBUV/2	318.5	334.6	315.5	392.1	384.6	396.9
(i) minus (ii)	-2.0	-1.9	-2.1	-7.6	-7.0	-6.4

Table 2(b): Examples of Consistency in Year-to-year Changes (in DU)

Data Set	35S-40S		45N-50N	
	OCT 05 minus OCT 04	OCT 06 minus OCT 05	MAR 06 minus MAR 05	MAR 07 minus MAR 06
(i) OMI	16.2	-19.3	-6.9	12.9
(ii)SBUV/2	16.1	-19.1	-7.5	12.3
(i) minus (ii)	0.1	0.2	0.6	0.6