Solar Backscatter Ultraviolet Sounder (SBUS) on FY-3 and Primary Comparison of Measurements with SBUV/2 on NOAA

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ABSTRACT

The solar Backscatter Ultraviolet Sounder (SBUS) is the first remote sensing instrument carried on Chinese Meteorological Satellite to monitor global ozone distribution and variation. As one of the main payloads on FY-3 satellite, the second generation polar orbit satellite of China, SBUS was launched in May of 2008. In this paper, we introduce the basic characteristic of SBUS and carried some primary comparison between SBUS and SBUV/2 on NOAA satellites. The comparisons include three parts: direct solar irradiance measurements, N-values and retrieved ozone profiles from the measurements. Primary comparisons show that the precision of measurements from SUBS is quite good. Quantitative evaluation will be carried out in the future.

1. Characteristics of the SBUS on FY-3

As one of the main payloads on FY-3 satellite, the second generation polar satellite of China, the Solar Backscatter Ultraviolet Sounder (SBUS) was launched on 27, May of 2008. SBUS is the first one of this kind of instrument made by China and carried on Chinese meteorological satellite. As part of the global earth observing net, SBUS data of ozone profile products will be open and shared among users of the whole world, and contribute to monitoring global ozone variation.

The design of SBUS is similar with SBUV/2 on NOAA satellites. Like SBUV(/2), SBUS uses a double mono-chromator to measure backscattered ultraviolet radiances in 12 fixed wavelength bands with 1.1nm bandwidth. The nominal wavelengths and bandwidths of SBUS are given in table 1.

Table 1. The nominal wavelengths and bandwidths of FY-3/SBUS

Channel	Central wavelengths (nm)	bandwidths
1	251.997	1.16
2	273.605	1.12
3	283.089	1.14
4	287.693	1.13
5	292.287	1.12
6	297.585	1.12

7	301.956	1.12
8	305.869	1.12
9	312.551	1.13
10	317.549	1.10
11	331.250	1.10
12	339.882	1.08
Photometer	379.45	3.30

SBUS observes the earth in the fixed nadir direction with an instantaneous field of view (IFOV) on the ground of about 200 by 200km. It steps through the 12 channels in 64 seconds. During the 64-s scan time, the satellite moves about 400km along the tracks, so there is an averaged 34km gap between IFOV of one channel to another. To monitor the possible change of scene reflectivity due to the motion of satellite during the scan, a separate coaligned filter photometer centered at 379nm makes 12 measurements concurrent with each of the 12 monochromator measurements.

SBUS have 3 main working modes in orbit. They are solar irradiance observation, the backscattered radiance observation and standard lamp calibration. The third mode is used to monitor and correct the possible wavelength shift during the in orbit period. The measurements of albedo, ratio of the solar irradiance and radiance, are used to deduce the ozone profile products. The n-value variable, used in the retrieval, is defined as follower:

$$N_\lambda = -100 \bullet \log \frac{I_\lambda}{F_\lambda}$$

Where the I_λ and F_λ are backscattered radiance and irradiance at wavelength λ respectively.

2. Comparison of measurements from SBUS and SBUV/2

2.1 Comparison of irradiance measurements

Both SBUS and SBUV/2 have discrete solar irradiance observing mode. Table 2 gives the comparison of irradiance measurements from SBUS and SBUV/2.

Table 2.Comparison of Irradiance measurements from SBUS and SBUV/2

SBUS-WV	N17-WV	N18-WV	C1	C2
251.997	251.911	252.039	-5.9	-9.5
273.605	273.509	273.702	9.9	0.2
283.089	283.049	283.164	4.7	4.9
287.693	287.619	287.732	8.9	5.5
292.287	292.178	292.364	7.3	5.3
297.585	297.534	297.643	-1.2	0.2
301.956	301.925	302.032	1.6	1.3

305.869	305.795	305.901	0	-1.8
312.551	312.494	312.671	-1.4	-1.4
317.549	317.503	317.604	-2.6	-4.1
331.25	331.222	331.318	-1.2	-1.1
339.882	339.83	339.923	-8.7	-7.9

In table 2, Column 1 is the FY-3 SBUS central wavelengths. Column 2 is the NOAA-17 SBUV/2 central wavelengths. Column 3 is the NOAA-18 SBUV/2 central wavelengths. Column 4 is the percent differences in irradiances NOAA-17 SBUV/2 and FY-3 SBUS. Column 5 is the percent differences in irradiances NOAA-18 SBUV/2 and FY-3 SBUS.

From table 2, we see some of the differences of the measurements of solar irradiance between SBUS and SBUV/2 are as big as almost 10 percent. We expect some differences due to the difference of wavelengths between SBUS and SBUV/2. In table 3, we use the NOAA-16 SBUV/2 data to show how much the solar irradiance changes over each 0.15nm.

Table 3.Percent changes in the solar irradiance data over each step

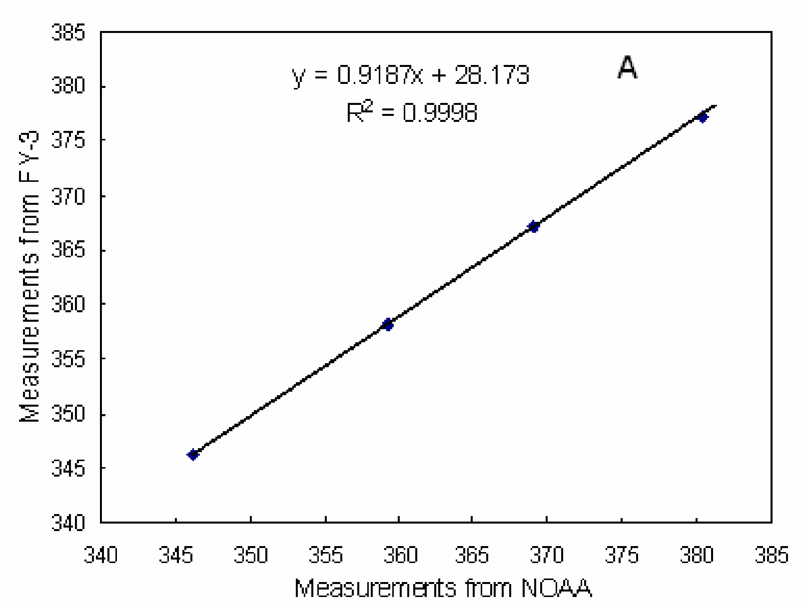
Wavelength	Position 1	Position 2	Position 3
251.951	-2.2	3.1	5.3
273.677	-1.5	8.4	9.9
283.134	1.2	1.0	-0.2
287.699	-2.8	2.3	5.1
292.255	-1.0	2.2	3.2
297.532	3.0	-3.3	-6.3
301.919	-0.7	-0.6	0.1
305.859	-2.5	2.0	4.5
312.552	0.0	-0.9	-0.9
317.629	-1.9	2.6	4.5
331.191	-0.3	0.2	0.5
339.935	1.6	-1.3	-2.9

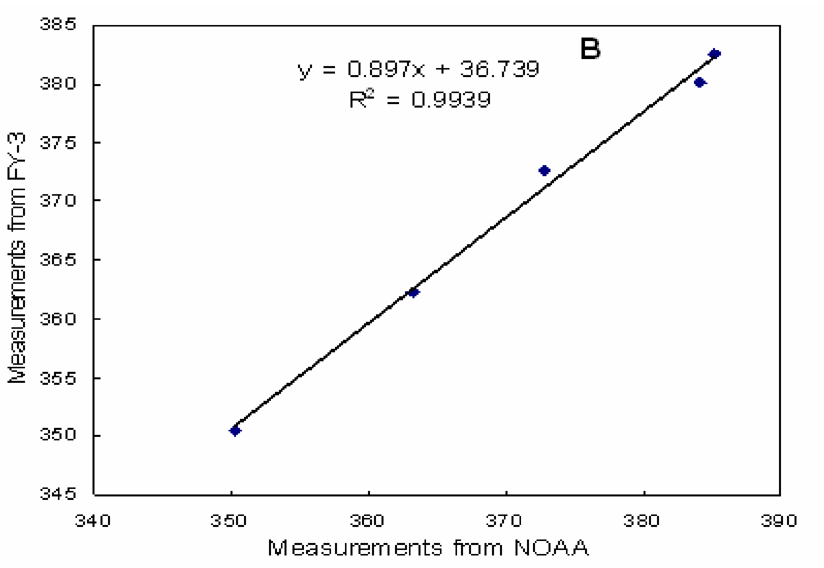
In table 3, the first column is the middle wavelengths. The next three columns are percent changes in the solar between three consecutive measurements. The second column is the change in solar irradiance between the middle wavelength and the next shorter one. The third column is for the middle and the next longer one. The fourth column is the difference between the shorter and longer wavelengths -- they are separated by approximately 0.3 nm. This gives us an idea how much of the differences among the SBUV/2 and SBUS instruments might be because their wavelengths differ a little.

2.2 Comparison of N-values

The solar backscattered technique uses N-value variables to deduce atmospheric ozone information. The precision of N-values is much more important than the absolute irradiance calibration. Considering characteristics of ozone absorbing ultraviolet, we find N-values at wavelengths shorter than 290nm are hardly affected by surface and land cover. To carry out comparison of N-values between SBUS and SBUV/2, we choose comparable IFOVs from SBUS and SBUV/2 observing data at same date. Here, the comparability of IFOVs is defined as that difference of solar zenith angle (SZA) and latitude and longitude are smaller than 0.5 degree. From 17 to 30 of July, we find about 60 profiles meeting these demands.

Figure 1 give some comparison results at wavelengths of 252, 274,283,288 and 292nm from FY-3 SBUS and NOAA-17 SBUV/2.





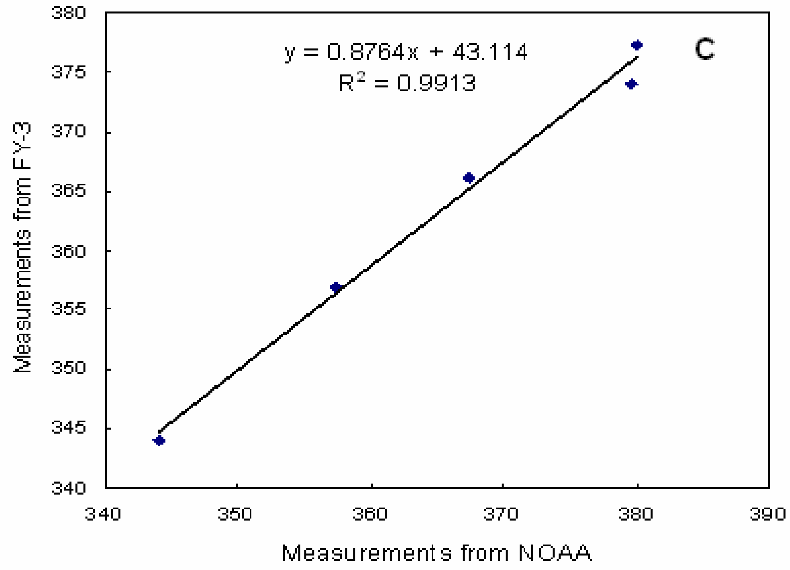


Fig 1. Some comparison results of N-values

Table 4 shows the similarities in solar zenith angle (SZA) and latitude and longitude for the compared data in figure 1.

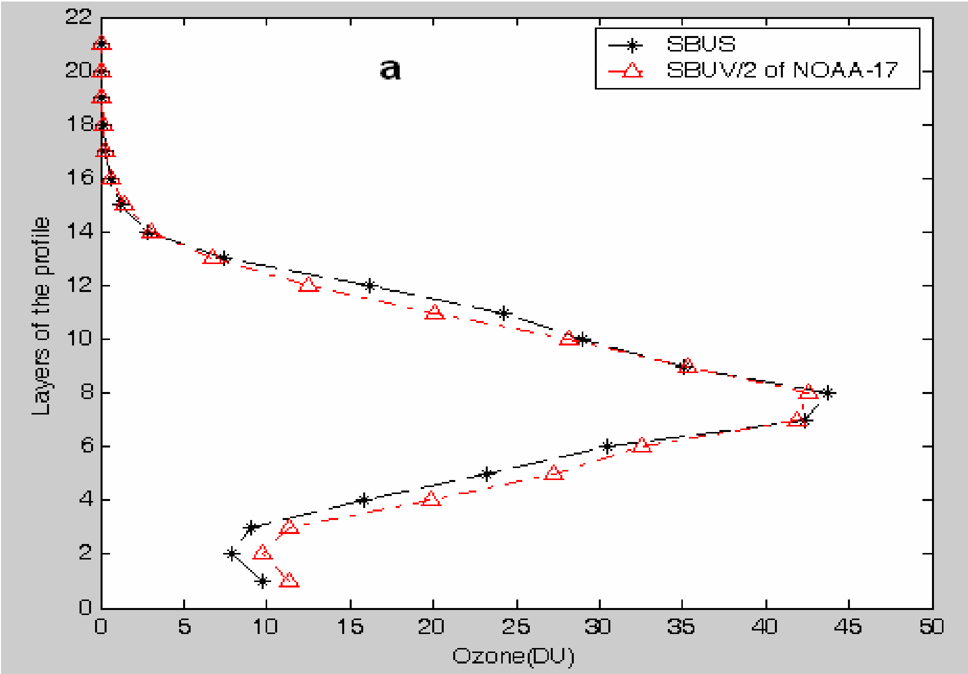
Table 4. The similarities of the compared data in figure 1.

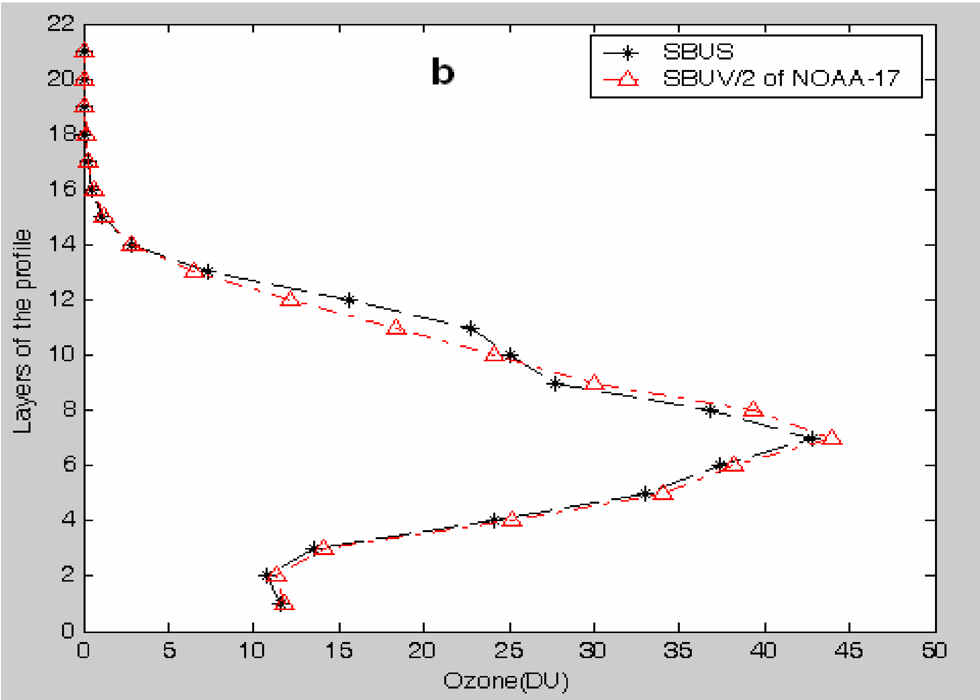
Date	instruments	SZA(deg)	Location(deg)
A 20080717	FY-3 SBUS	64.487495	Lat=81.221367,Lon=-12.911753
	NOAA-17 SBUV/2	64.813637	Lat=81.452690,Lon=-13.095590
B 20080717	FY-3 SBUS	67.346252	Lat=80.793861,Lon=-17.861513
	NOAA-17 SBUV/2	67.627548	Lat=80.69051,Lon=-17.756449
C 20080717	FY-3 SBUS	62.923748	Lat=80.9148861,Lon=-122.535919
	NOAA-17 SBUV/2	63.22417	Lat=81.31201,Lon=-122.582268

From figure 1, we can see that N-values at 5 short wavelength channels from SBUS are quite consistent with that from SBUV/2 at selected profiles. As for the comparable 60 profiles, the averaged difference of N-values is about 5.8%.

3. Comparison of derived ozone profiles from SUBS and that of SBUV/2

Much more directly, we compare retrieved ozone profiles from SBUS with those from SBUV/2. Figure 2 show some comparison results of ozone profiles retrieved from SBUS measurements and that from SBUV/2 at IFOVs with similar SZA and latitude and longitude.


a
SBUS
SBUV/2 of NOAA-17
Layers of the profile
Ozone(DU)
0
2
4
6
8
10
12
14
16
18
20
22
0
5
10
15
20
25
30
35
40
45
50


b
SBUS
SBUV/2 of NOAA-17
Layers of the profile
Ozone(DU)
0
2
4
6
8
10
12
14
16
18
20
22
0
5
10
15
20
25
30
35
40
45
50

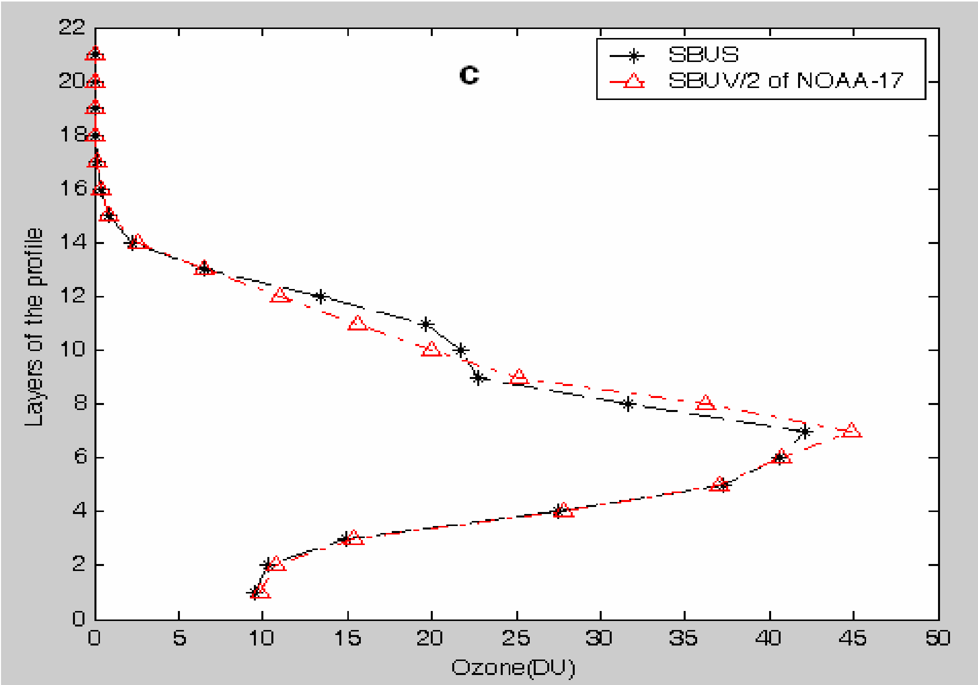


Fig 2. Some comparison results of retrieved ozone profiles

Table 5 gives the similarities of SZA and location for the comparisons.

Table 5. The similarities of the comparisons in figure 2.

Date	Instruments	SZA(deg)	Location(deg)
a 20080723	FY-3 SBUS	45.216248	Lat=64.45257,Lon=178.3881
	NOAA-17 SBUV/2	45.544125	Lat=64.043037,Lon=178.292587
b 20080723	FY-3 SBUS	47.89875	Lat=67.4499436,Lon=156.22023
	NOAA-17 SBUV/2	48.030472	Lat=67.070915,Lon=156.041061
c 20080719	FY-3 SBUS	70.241249	Lat=79.549698,Lon=134.156174
	NOAA-17 SBUV/2	70.30732	Lat=79.287285,Lon=134.430832

From figure 2, we can see the consistencies of the retrieved profiles from SBUS and SBUV/2 are quite good. The averaged difference is about 8-10% at most levels.

4. Conclusions

Primary comparison of measurements and retrieved profiles from SBUS on FY-3 satellite with that from SBUV/2 on NOAA satellites show that precision of data from SBUS is quite good at present. The primary estimated precision of retrieved ozone profile from SBUS is about 8-10% at most levels relative to SBUV/2. In the future, we need much more comparison of retrieved ozone profiles and surface ozone sonde data to carry out quantitative evaluation for SBUS.