

The Impact of Using Different Ozone Cross Sections on Ozone Profile Retrievals from OMI UV Measurements

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ACSO Meeting, WMO, Geneva

June 3, 2013

Outline

- Introduction
- **OMI Ozone Profile Retrieval Algorithm**
- **Comparison of Quadratic Parameterization**
- Comparison of OMI Retrievals with Different Cross Sections
- Validation of OMI Retrievals with Ozonesonde Observations
- **Summary**

Introduction

- Liu et al. (2007) studied impact of O₃ cross sections on GOME O₃ profile retrieval (290-307 nm, 326-340 nm)
 - **4 BP, BDM, GOME-FM: significantly impact retrievals**
 - **Recommended to use BDM:** smaller residuals in Huggins bands (0.1% vs. 0.12-0.25% for BP), better agreement with ozonesonde
- Call for better cross sections
 - **4** BDM (218 K, 228 K, 273 K, 243 K, 295 K): inadequate Temp. range
 - **4** Temperature dependence does not cover beyond 620 nm
- Before ACSO's request last October, performed initial testing of using Serdyuchenko et al. cross sections
- Test the impacts of cross sections on OMI ozone profile retrievals from UV spectra in the Hartley and Huggins bands
 - **4** Very sensitive to the quality of ozone cross sections
 - **4 OMI: 269-330 nm** (269-309 nm, 312-330 nm), not much spectral gap

3

↓ BP, BDM, Serdyuchenko et al. → SGWCB

OMI Ozone Profile Retrieval Algorithm

- Perform spectral fitting with VLIDORT calculation of radiances and weighting functions, optimal estimation (Liu et al., 2010a, b)
- **Retrieve O₃ partial columns at 24 layers from surface to ~60 km**
 - **4** Fitting window: 269-309 nm, 312-330 nm
 - **+ Pre-determined** Gaussian slit widths for each fitting window, convolve high-resolution cross sections
 - **4** Fit wavelength shifts between radiances and irradiances, radiances and O₃ cross sections
 - **4** Use daily NCEP Global Forecast System (GFS) FNL data (1°× 1°) to account for temperature dependence: interpolated to OMI overpass
 - **4** Turn off soft calibrations (derived using BDM), no common mode
- Cross sections
 - **4** BP (original quadratic), vacuum, +0.015 nm, (Orphal&Chance, 03)

Residuals after Quadratic Parameterization



SGWCB: Residuals of >3% at some wavelengths & temperatures. BDM: Much smaller residuals without including 273 K.

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Cross sections

- **4** BP (original quadratic), vacuum, +0.015 nm, (Orphal&Chance, 03)
- **4** BDM (quadratic, derived without using 273 K)
- **4** SGWCB: Parameterized quadratic SGWCB (P. SGWCB)
 - Original data with interpolation/extrapolation (M. SGWCB)

Comparison of Quadratic Parameterization

 SGWCB: -2 to 4% wrt BDM
 BP: 1-2% below 315 nm, but larger oscillations of up to ± 6%
 Distinct differences among C₁ and C₂, indicating different temperature dependence.





BDM: Smoother
SGWCB: More fine structures
BP: Spiky especially in C₂

Comparison of OMI Fitting Residuals



1 orbit (2007m0714), nadir position: overpass S. and N. America
 Converged pixels: 1451, 1265, 816, and 633 pixels for BDM, BP, P. SGWCB, and M. SGWCB, respectively.

Similar fitting residuals for BDM and SGWCB, suggesting similar wavelength calibration and precision.

Much larger fitting residuals for BP in UV2, suggesting BP data are nosier₈ and may have wavelength calibration problems.

Comparison of Wavelength Shifts in O₃ Cross Sections



Not much latitudinal dependence for BDM and SGWCB.

BDM: -0.009±0.006 nm (UV1) -0.002±0.001 nm (UV2) SGWCB: 0.0015±0.004 nm (UV1) 0.005±0.001 nm (UV2) BDM/SGWCB: ~0.01 nm in UV1 ~0.007 nm in UV2

■ BP: significant latitudinal dependence especially in UV2, suggesting wavelength dependent errors

Comparison of Total Ozone Columns



Significant difference and latitudinal dependence

- **BP: generally within 5 DU except for up to 30 DU at 40°S-60°S**
- **SGWCB: -15 to 15 DU, smaller for P. SGWCB**
- **Well explained by difference in temperature dependence as** $R(\Delta O_{10}^{3}, T)$ **is ~-0.70.**

Comparison of Tropospheric Ozone Columns



- Significant difference and latitudinal dependence
- BP: generally within 5 DU
- **P. SGWCB: within** 5-10 DU, M. SGWCB: within 5-20 DU
- **R**(ΔO_3 , T) is ~-0.62 for M. SGWCB, smaller for other X-Sections¹¹

Comparison of Mean Ozone Profile



Generally within 10% above 20 km

 Large oscillations of up to ±20-40% for both BP and SGWCB with relative to BDM

Notice almost opposite bias patterns between BP and SGWCB with relative to BDM.

Linkages of O₃ Differences to Temperature Dependence



 Perform 12 orbits (1 orbit/month)
 ΔO₃, T at ~5, 15, 42 km for 40°-60°N
 At 5 km (300-330 nm), strong negative correlation of 0.7-0.95 for
 both BP & SGWCB when seasonal variation of T is significant.
 At ~42 km (<290 nm), strong negative correlation (0.75-0.88) for SGWCB

■ At ~15 km, smaller T variation, less significant R, 0.6-0.8 of R for BP.

Latitude Bands	Temp. Range (K) —			Correlation between O3 Rel. Diff. and Temperature								
				BP - BDM			P.SGWCB - BDM			M.SGWCB - BDM		
	5 km	15 km	42 km	5 km	15 km	42 km	5 km	15 km	42 km	5 km	15 km	42 km
60°N-40°N	24.3	11.02	38.4	<mark>-0.74</mark>	0.45	-0.35	<mark>-0.90</mark>	-0.24	-0.76	<mark>-0.95</mark>	-0.31	-0.80
40°N-20°N	15.9	16.6	12.8	<mark>-0.76</mark>	<mark>-0.78</mark>	0.28	-0.57	-0.56	0.10	<mark>-0.75</mark>	-0.46	-0.55
20°N-0°	6.4	4.0	9.1	-0.10	<mark>-0.61</mark>	-0.03	-0.21	-0.42	0.32	-0.22	-0.30	0.45
0°-20°S	5.6	5.3	9.4	-0.16	0.07	-0.16	-0.62	0.08	0.47	<mark>-0.74</mark>	-0.08	0.45
20°S-40°S	15.4	15.6	19.7	<mark>-0.86</mark>	<mark>0.64</mark>	-0.38	-0.42	-0.56	-0.81	-0.37	-0.39	-0.80
40°S-60°S	18.2	11.0	34.0	<mark>-0.78</mark>	-0.15	-0.31	- <mark>0.76</mark>	-0.25	-0.85	<mark>-0.78</mark>	-0.53	-0.88

T range and $R(\Delta O_3, T)$ for different latitude 13 bands.

Validation with Ozonesonde Observations













BDM: generally within 10%, much smaller std. dev. at mid./high latitudes

■ Large oscillations of up to ±20-70% below 20 km for both BP and SGWCB, with patterns similar to those between BP/SGWCB with relative to BDM.



Summary

- We compared BP, BDM, SGWCB cross sections in the Hartely and Huggins bands and evaluated the impacts of using these cross sections on OMI ozone profile retrievals (269-309 nm, 312-330 nm).
- Significant difference in C₀ and temperature dependence (C₁, C₂).
- **BDM/SGWCB** have similar wavelength calibration and precision, BP data are noisier.
- The use of cross sections significantly affects retrievals: TOZ/TOC may differ up to 15-20 DU. Differences between BP/SGWCB and BDM show ±20-40% biases below 20 km, and sometimes show strong correlation with temperature.
- BDM retrievals agree well with sondes to ~10%. BP/SGWCB retrievals show large oscillations of up to ±20-70% below 20 km.
- Recommend BDM for ozone profile retrievals from the UV (likely due to better temperature dependence).