Satellite and Ground-based Total Column Ozone Comparisons- Latest Results and Remaining Issues

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INTRODUCTION

Several of the NASA satellite-based total column ozone datasets have been reprocessed recently. The accuracy of the newly reprocessed Earth-Probe TOMS and the new OMI/TOMS Version 8.5 algorithm (Collection 3) are shown as are comparisons of these new products with available Dobson and Brewer groundstation data. Also, a summary of remaining issues affecting both satellite and ground based ozone retrievals will be presented. This includes such issues as effects of possible errors in ozone cross sections, ozone profile shape effects, SO2 and aerosol contamination, stray light effects, and errors in assumed cloud heights. The effect of possible errors each of these assumptions have on the current ozone retrieval algorithms will be shown.

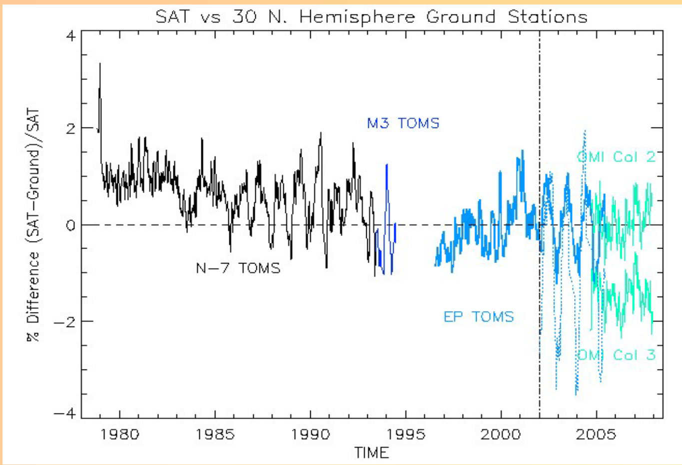

Figure 1: TOMS & OMI vs an ensemble of 30 Northern Hemisphere groundstations

Figure 1 shows the comparisons between satellite and ground-based weekly averaged total ozone measurements since 1978.
Nimbus-7 TOMS changed response characteristics in 1983-4 for reasons that are not understood.
Meteor-3 TOMS ozone values were limited to +/- 3 hours of noon.
Earth Probe TOMS optics have degraded over time causing a complex change in the instrument's sensitivity. Due to diminished accuracy resulting from this degradation, EP/TOMS total column ozone data from 2002 to the present are not recommended for the calculation of long-term ozone trends. Attempts to correct the data based on physical principles and internal diagnoses have previously been unsuccessful. Comparisons with NOAA-14 and NOAA-16 have been used to derive empirical corrections for the ozone absorbing channels while purely internal validations are used to derive corrections for the non-absorbing channels. Comparisons show that the accuracy of the EP-TOMS retrievals after the calibration adjustment has increased significantly and the corrected data are now near-trend quality, but can no longer be considered an independent measurement of ozone after year 2002.
AURA-OMI total ozone data (OMTO3) have recently been reprocessed with a new calibration and dark count correction (Collection 3). The comparisons with the ground-based data show a –1.5% offset. While it is possible that the new calibration is incorrect, we must stress that the absolute ozone values are not known to the 1% level of accuracy. *WHY? That's the topic of this poster.*

An Incomplete List of Remaining Issues

- Ozone profile shape effects
- Ozone cross section errors
- SO_2 contamination
- Instrumental stray light
- Aerosols
- Cloud heights/assumptions

1) Ozone Profile Shape effects

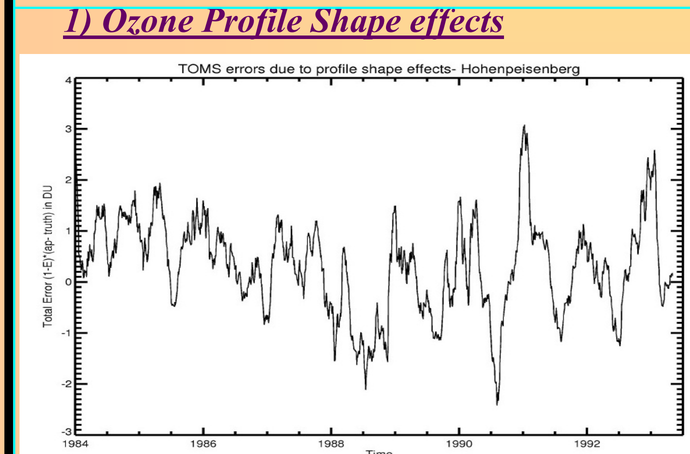

Figure 2: The error in the TOMS retrievals due to profile shape effects. The real profile (as measured by ozonesondes) are put into the TOMS retrieval algorithm and the retrieved total column ozone amount is then compared to the standard retrieval (V8) which uses a climatology.

2) Ozone Cross Section Errors

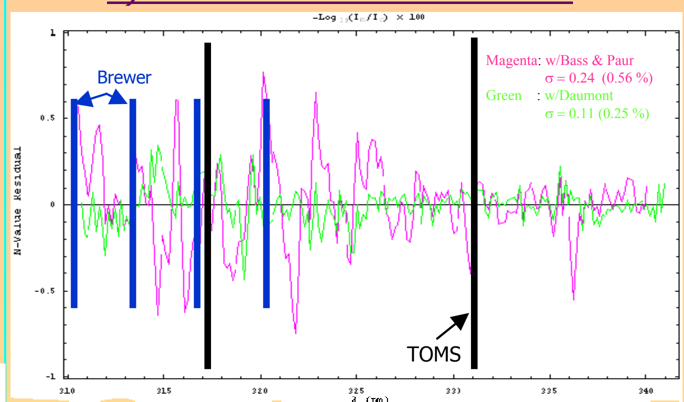

Figure 3: Comparison of OMI Residuals for One Clear Sky Pixel. This represents the remaining signal after all known absorbers have been removed (O_3, SO_2, NO_2, Rayleigh). The Daumont cross sections exhibit a much "cleaner" residual.

Possible Errors due to Cross Sections

@ -44C	B&P	Daumont	Diff(%)
Dobson A-D	1.432	1.430	0.0
Dobson C-D	0.459	0.461	-0.3
TOMS V8	0.319	0.314	1.5
Brewer	*0.338-.347*	*0.357-.364*	-4.6

(The Brewer weighting functions will have to change)

Uncertainties in Dobson slit positions

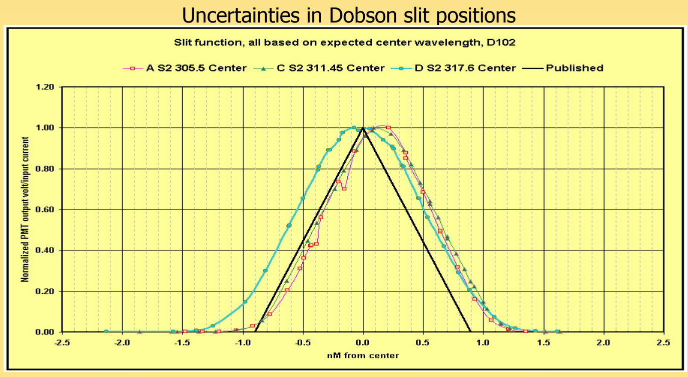

Figure 4: Assumed vs measured Dobson cross sections. Dobson #102 measured the output of a tunable dye laser and the relative slit functions were produced. A and C wavelengths were slightly longer than assumed and D short was significantly wider *for this particular instrument.* It is not currently known if this is a typical Dobson slit function or an anomaly. The difference between the measured ozone cross-sections and the assumed are: AD=2.6% CD=3.6% (ozone will be higher by this amount *for this instrument*)

3) SO2 Contamination

SO_2 is problematic for both satellite and ground-based ozone retrievals. The Brewer spectrophotometer standard algorithm retrieves ozone and SO_2 using the longest 4 wavelengths. If the shortest 2 channels are added and then ozone and SO_2 are retrieved simultaneously the signal appears "cleaner" (blue line) for both species.

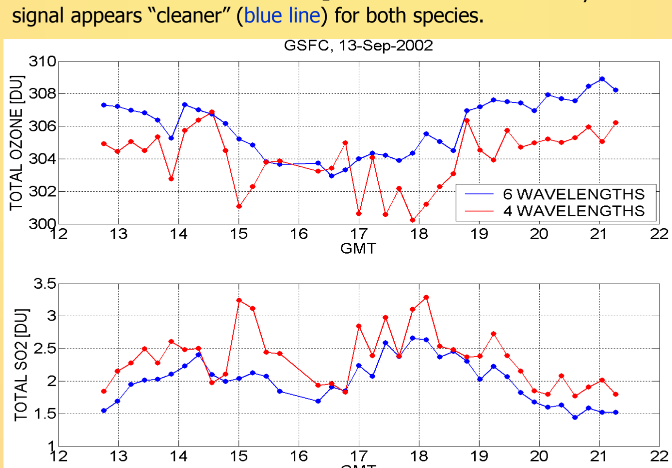

Figure 5: Ozone and SO_2 retrieved for a single day at Goddard Space Flight Center using the standard retrieval method (red line) and a 6 channel method (blue line).

SO_2 also causes problems with satellite ozone retrievals. Volcanic eruptions can cause an overestimation of column ozone.

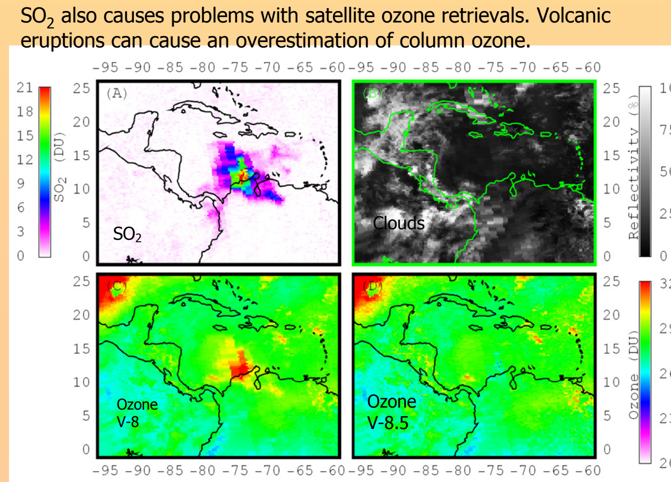

Figure 6: SO_2 contamination of OMI retrieved ozone in Version 8 (lower left panel) and with the new Version 8.5 (lower right). The ~20DU error has now been removed.

4) Stray light issues

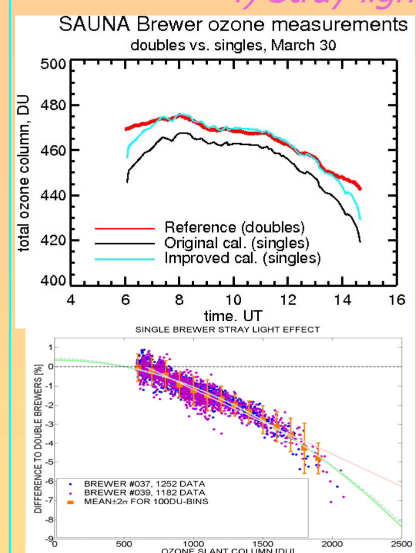

Figure 7: Errors due to stray light in the Brewer single spectrophotometer instrument. When compared to the MK-III doubles at high path lengths, it is easy to see the underestimation of column ozone amounts. New calibration techniques are being developed to minimize this problem.

5) Errors due to clouds

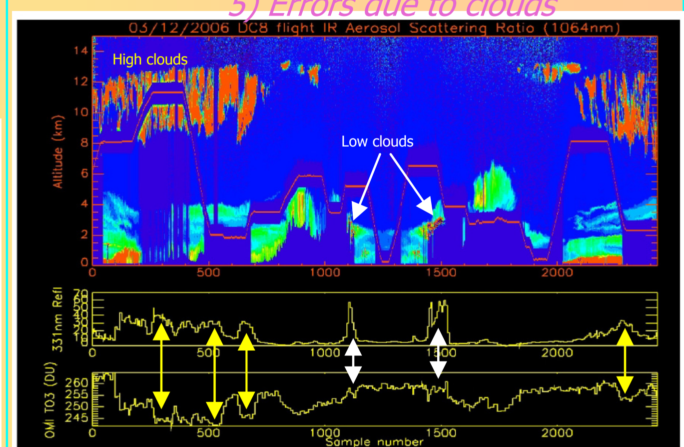

Figure 8: Lidar measurements taken from DC-8 aircraft showing cloud height and thickness. The aircraft altitude & track is represented by the orange line. The OMI collocated overpass ozone values and reflectivity values are shown as well. They indicate that in the presence of low clouds, the OMI retrieval assumptions are correct, but when high clouds are present, their signature in the column ozone values is apparent which indicates an error in the retrieved values.

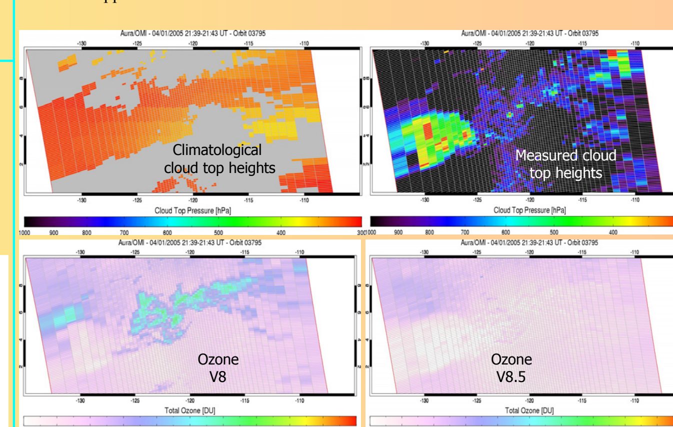

Figure 9: OMI ozone retrievals using the climatological cloud top heights (left panels) and using the measured cloud top heights from the Raman scattering method (right panels). For more information, see poster by K. Yang.

Error Budget & Conclusions

Error Budget	Satellite		Ground-based	
	V8	V8.5	Dobs	Brew
Profile Shape/Peak Height	<0.5%		<1.5%	<0.5%
Cross Section Errors	~1.5%	<0.1%	<0.3%	??
SO_2 Contamination(urban)	<0.5%		<3.0%	<1.0%
SO_2 Contamination(volcanic)	<15%	<3.0%	<25%	Unk
Stray Light	<1.0%		<	<7.0%
Cloud Height Errors	<10.0%	<3.0%	N/A	

Cross section errors are probably the easiest to correct and this author recommends switching from Bass & Paur to Dumont as soon as possible. The temperature dependent changes in B&P are likely in error at lower (<-55C) temperatures. This would involve re-weighting the Brewer ozone retrieval coefficients. SO2 contamination can be corrected by reprocessing the OMI data and by applying a 6 wavelength retrieval to the Brewer algorithm (for double Brewers). Cloud height errors are the most prevalent errors in the TOMS/OMI ozone retrievals and can be corrected by measuring the Raman scattering at ~350nm to retrieve cloud top heights. Once The true cloud heights are known, the satellite column ozone retrievals are quite accurate. Ongoing work for the upcoming Version 9 algorithm includes: improved radiative transfer calculations, better Ring correction (Raman scattering), better surface reflectivity climatology, corrected high SZA retrievals, SO_2 filtering and better pseudo-spherical approximations.

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