Comparison of Ozone Retrievals from the Umkehr Reprocessing version and Satellites

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Introduction

The long-term record of Umkehr measurement by the NOAA Dobson spectrophotometer has been reprocessed by updating calibration procedures and applying new quality-controlled tool under the updated Dobson automation software. In this study we present comparison of Dobson Umkehr ozone profiles from three NOAA ozone network stations (Boulder, Mauna Loa and Lauder) against satellite overpass data, i.e. Aura Microwave Limb Sounder (MLS; ver. 4.2) and Ozone Mapping Profiler Suite (OMPS) and SBUV (ver. 8.6) overpasses. The satellites data are spatially (less than 200 km) and temporally (within 24 hours) matched with Dobson Umkehr measurements at the station. The retrieved individual Umkehr Averaging Kernels (AKs) are applied to smooth the overpass satellite profiles prior to comparisons.

- This work understands overall quality from comparison with retrieved Umkehr layer ozone and a satellite.
- The issue of the shift accompanying Dobson calibration and stray light error needs to be evaluated.

Comparison with satellites.

The long-term NOAA Dobson Umkehr ozone record (blue) was re-processed in WinDobson software. The new Umkehr data are compared with overpass SBUV (Solar Backscatter UV), MLS (Microwave Limb Scatter) and OMPS (Ozone Mapping and Profiler Suite) satellite observations (red). The relative difference between Umkehr and each satellite is plotted as ozone monthly averages (green). Results are shown for Boulder (40 N), MLO (19.5 N) and Lauder (45 S) and demonstrate differences in three geographical areas.

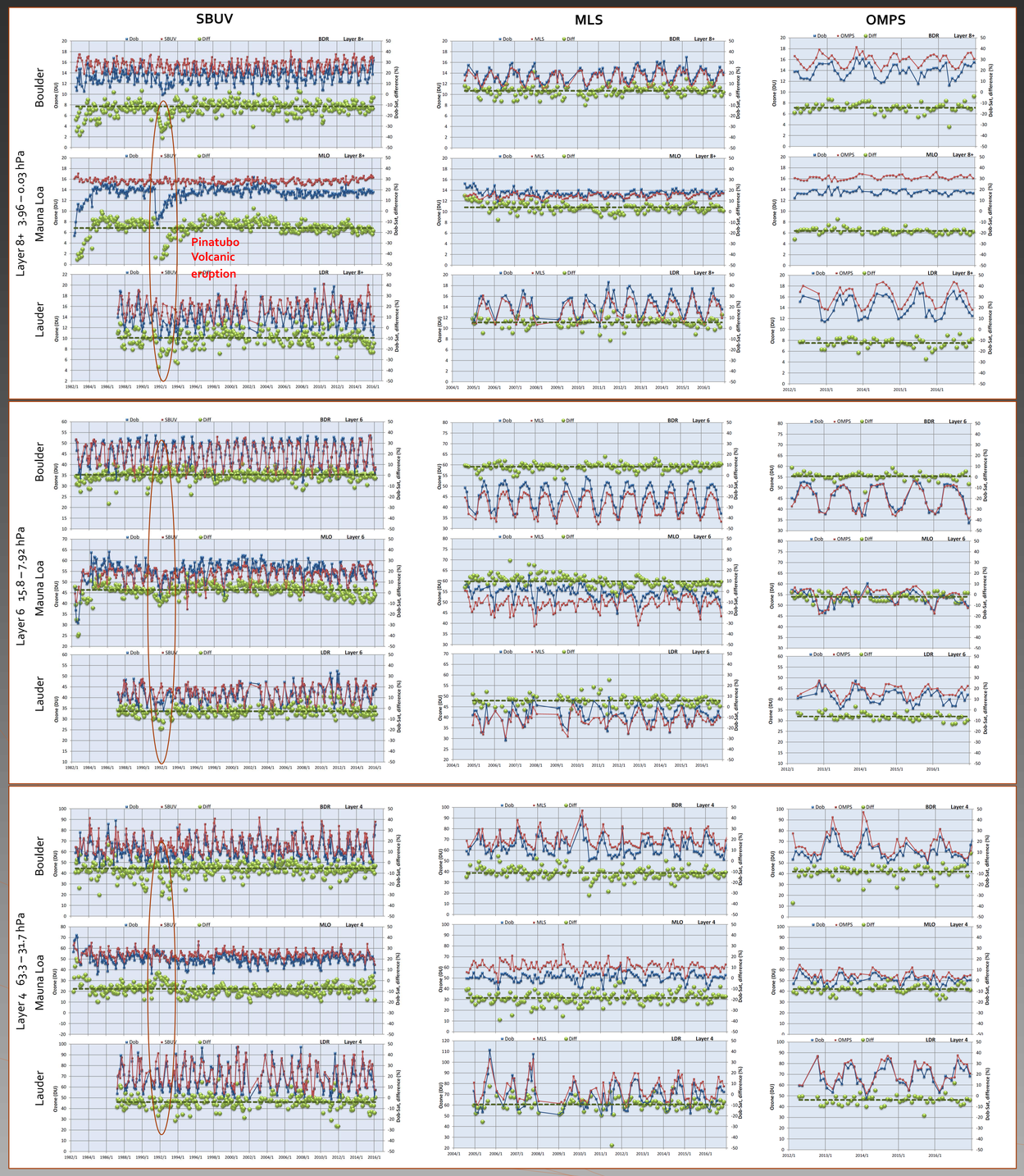
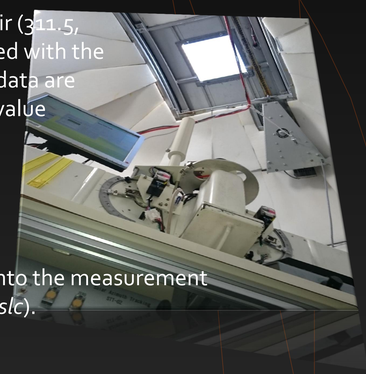


Figure 1. Monthly mean relative differences between Dobson Umkehr layer ozone and SBUV (left panel), Aura MLS (mid panel) and OMPS (right panel). The Umkehr and satellite obsercvations are matched to less than 24 hours. The plot shows the percent difference (Green dots), Dobson (Blue line) and satellite (Red line) ozone in DU. The red ovals mark errors in Umkehr retrieval due to Pinatubo volcanic aerosol interference with obs.

Umkehr Retrievals.

Dobson Umkehr measurements are made using the information from the C wavelength pair (311.5, 332.4 nm). The algorithm for ozone retrieval, UMK04 (Petropavlovskikh et al., 2005) is provided with the ozone profile from two models (forward and inverse). Independent zenith sky cloud detector data are used for screening of N-value measurements for interference od clouds in the zenith view. N-value measured is described (as I/F are zenith-sky intensity/Solar flux) at 2 spectral channels.



$$N(w,Z) = 100 * log_{10}\{\frac{I_{(w,z,Ls)}}{I_{(w,z,Ll)}} / \frac{F_{(w,z,Ls)}}{F_{(w,z,Ll)}}\} + k$$

Stray light correction (SLC)

The Umkehr ozone profile processing is biased by the interference of out-of-band stray light into the measurement (Petropavlovskikh et al., 2011). The algorithm takes into account the stray light correction (d*Nslc*).

$$N_{slc} = N(w,Z) + dNslc(O_3, P, Z)$$

dN_{slc} is estimated from look up tables that are dependent on latitude, altitude (p), solar zenith angle (z), and total ozone (O_3).

Summary and Discussion.

Umkehr retrieval ozone is compared with the satellite overpass over three NOAA Dobson stations . Results in stratosphere are quite similar for 3 stations. However, the Umkehr/SBUV comparisons in the lower stratosphere at MLO is inconsistent with results at two other stations. Comparisons show good agreement in the middle stratosphere (Umkehr layers 5–7) and in the upper stratosphere (layer 8 and combined layers 8, 9, and 10). However, in the lower stratosphere (Umkehr layers 2-4) relatively difference can be as large as 20 %.

Table 1. Summary of difference of Dobson Umkehr layer ozone and satellites from Figure 1.

Pressure [hPa]			Boulder						Mauna Loa						Lauder					
			SBUV		MLS		OMPS		SBUV		MLS		OMPS		SBUV		MLS		OMPS	
Bottom	Top	Layer	%	sdv	%	sdv	%	sdv	%	sdv	%	sdv	%	sdv	%	sdv	%	sdv	%	sdv
506.63	253.31	1	16.2	17.5			17.3	11.1	-10.4	15.7			-1.2	8.9	9.8	17.4			10.6	7.7
253.31	126.66	2	9.6	14.4			9.3	8.7	-10.7	13.3			-3.9	7.4	7.8	14.9			8.4	7.2
126.66	63.328	3	0.2	8.2	-21.3	9.6	-2.4	5.9	-11.1	9.9	-19.9	9.8	-7.8	5.9	2.7	7.9	-18.4	11.0	2.5	5.2
63.328	31.664	4	-5.5	5.0	-11.2	5.4	-8.0	7.1	-7.6	5.4	-18.4	5.7	-7.9	4.0	-3.9	6.2	-9.3	6.9	-3.8	4.8
31.664	15.832	5	-2.3	4.8	2.9	5.1	-2.5	4.2	-0.9	6.1	-7.1	3.1	-4.8	3.2	-5.4	8.8	2.4	8.1	-5.6	4.5
15.832	7.916	6	0.5	4.2	8.3	3.5	0.8	3.6	2.7	6.5	9.8	5.2	-2.0	3.4	-2.7	4.7	5.8	4.9	-6.1	3.4
7.916	3.958	7	-5.4	5.0	5.8	4.2	-6.3	3.7	-6.4	6.8	11.0	3.4	-9.8	2.4	-5.6	5.2	4.9	4.1	-10.4	2.6
3.958	1.979	8	-12.1	5.7	3.0	5.0	-14.3	5.0	-16.6	13.0	4.4	4.4	-18.6	3.0	-10.1	8.2	5.2	5.1	-13.3	4.9
3.958	0.031	8+	-11.4	5.2	3.4	4.4	-13.9	4.7	-15.9	11.5	4.1	4.1	-18.0	2.8	-9.5	7.6	5.6	4.8	-12.4	4.5

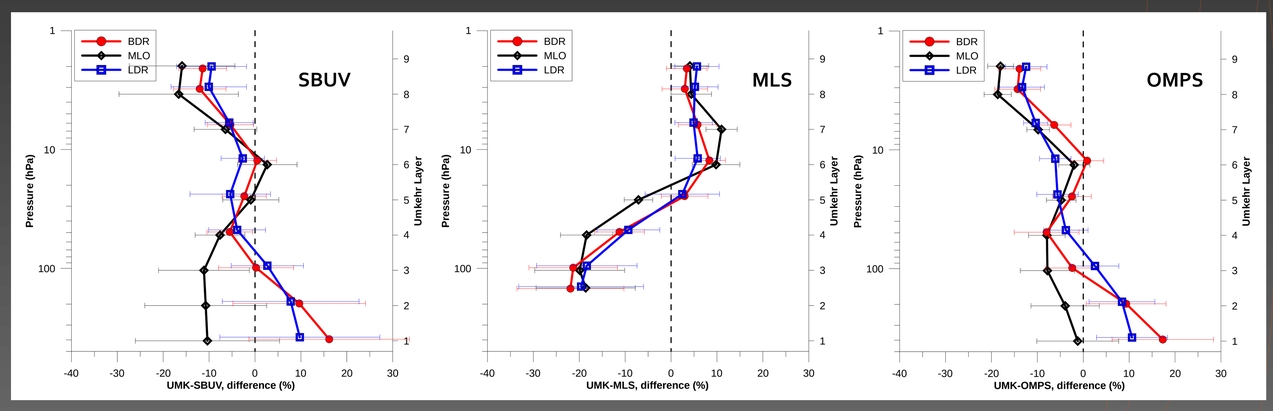


Figure 2. Shown are differences between Umkehr layer ozone and Aura MLS (2004-2016), OMPS (2012-2016) and SBUV (1982-2016). Satellite data are matched to Umkehr record (200 km less than overpass distance and within 24 hours of Umkehr measurement) at Boulder, Mauna Loa and Lauder stations. The error bar shows ± 1 standard deviation.

Stray light correction (SLC) evaluation

SLC leads to the increase in ozone in the upper stratosphere, and reduction in the lower stratosphere. In the upper stratosphere stray light error can be as large as ~8%.

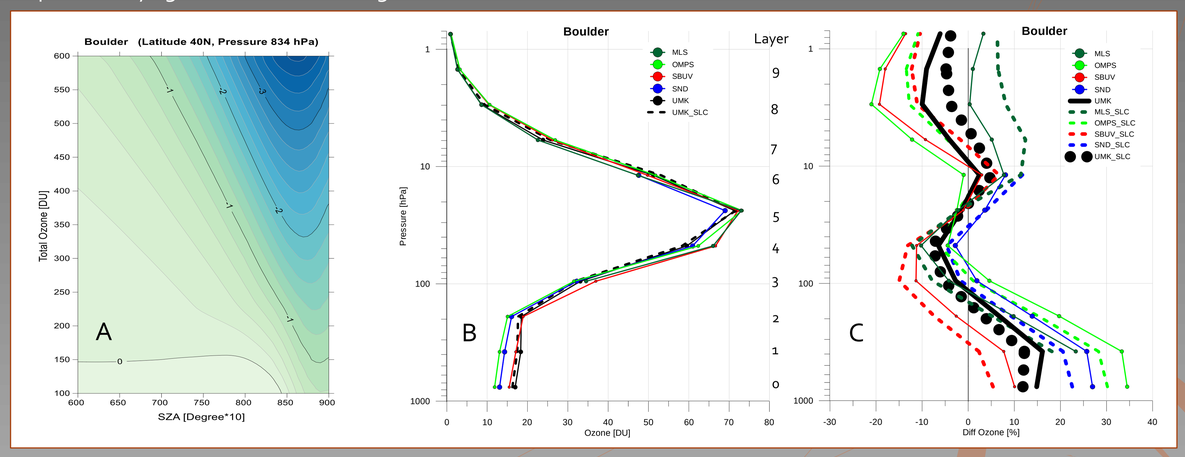


Figure 3. A) Stray light correction (N-value) is shown as function of solar zenith angle at Boulder. B) Mean Umkehr, MLS, OMPS, SBUV satellites, ozonesond are plotted as function of pressure. Also shown is Umkehr profile after Stray Light Correction applied. C) Individual ozone profile % difference is shown as ((UMK-satellite)/Mean*100). Solid line is a difference with UMK. A dotted line is Umkehr with applied SLC.

References.

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