Comparison of Ozone Retrievals from the Umkehr Reprocessing version and Satellites

K. Miyagawa1, I. Petropavlovskikh2,3, G. McConville3,4, A. McClure-Begley3,4, and R. D. Evans4

1 Guest Scientist at NOAA Earth System Research Laboratory, Global Monitoring Division (GMD), Boulder, CO 80305; 203-497-6679, E-mail: miyangawa.koji@noaa.gov
2 Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, CO 80309
3 NOAA Earth System Research Laboratory (ESRL), Global Monitoring Division (GMD), Boulder, CO 80305
4 Retired from NOAA ESRL, Global Monitoring Division (GMD), Boulder, CO 80305

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 satellite 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 with 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 (29.5 N) and Lauder (45 S) and demonstrate differences in three geographical areas.

Umkehr Retrievals.
Dobson Umkehr measurements are made using the information from the C wavelength pair (126.66, 126.66 nm). The algorithm for ozone retrieval (UMKo4, 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 of clouds in the zenith view. N-value measured is described as (I/IR) are zenith-sky intensity/Solar flux at 2 spectral channels.

\[
N(w, Z) = 100 \times \log_{10} \left( \frac{I_{w}}{I_{w+Z}} \right) + k
\]

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 (dnSLC) 

\[
dn_{SLC} = N(w, Z) + dN_{SLC}(O, P, Z)
\]

dnSLC is estimated from look up tables that are dependent on latitude, altitude (w), solar zenith angle (z), and total ozone (O).

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/SLC 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 B, g, and h). 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.

<table>
<thead>
<tr>
<th>Pressure (hPa)</th>
<th>Bottom</th>
<th>Top</th>
<th>Layer</th>
<th>MLO</th>
<th>LDR</th>
<th>BDR</th>
<th>NDVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Set</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBUV, MLS, OMPS</td>
<td>-8.6</td>
<td>12.5</td>
<td>7.1</td>
<td>4.5</td>
<td>3.0</td>
<td>2.0</td>
<td>3.4</td>
</tr>
<tr>
<td>SND_SLC, UMK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OMPS, UMK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. A) Stray light correction (N-value) is shown as function of solar zenith angle at Boulder. B) Mean Umkehr, MLS, OMPS, SBUV satellites, ozone 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.