Umkehr data Reprocessing version at the U.S. Dobson stations

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Introduction

The observed changes in the relative intensities of UV from the zenith sky as the sun rises and sets (called the Umkehr effect) are controlled by the ozone profile over the observation point. The relative intensities are measured over a solar zenith angle (sZA) range of 60-90 degrees, and combined in to units called N-values. A shape of this curve then can be used to determine the ozone profile in layers over the observation point [Götz, et al (1954)].

The Umkehr ozone profile processor provides information about inter-annual stratospheric profile ozone variability. Dobson Umkehr spectrophotometer measurements in the NOAA ozone network were first automated in the 1980s, improving traditional manual data acquisition of 1960-1970s. The noise and stability of the Umkehr measurement is estimated by the reference to the atmospheric variability captured by an independent zenith cloud detector (the intensity of light from the zenith monitored through a 862 nm interference filter), and by comparison with a reference N value curve, which is based on a standard ozone profile. Based on these analyses, the Umkehr measurement is either completely eliminated or adjusted according to the analysis. The Dobson total column ozone processing was recently updated and become available for the Umkehr ozone profile reprocessing. The differences in the updated Umkehr ozone profiles are assessed using satellite (MLS and OMPS) profiles.

Umkehr Measurement network

Figure 1. The six US network sites making Umkehr measurements with automated Dobson instruments.

Umkehr Retrievals

Dobson Umkehr measurements are made using the information from the C*. wavelength pair (313.5, 332.4 nm). The algorithm for ozone retrieval, Umkehr [Petropavlovskikh, et al (2003)] is provided with the ozone profile from two models (forward and inverse). Independent zenith sky cloud detector data can be used for revision of N-value curve when cloud passes through the zenith sky. N-value measured is given to a forward model below.

\[ N(w) = 100 \times \left( \frac{\text{N} \text{_{cloud}}}{\text{N} \text{_{sun}} + \text{N} \text{_{cloud}}} \right) \]

\[ \text{N}_{\text{cloud}} \] is estimated from look up tables that have latitude, altitude (g), solar zenith angle (z), and total ozone (O3) regression.

Umkehr Retention

Figure 2. Time series of the ozone profiles from the Umkehr and MLS observations at Boulder.

Figure 3. N-value curve and ozone retrieval profile. The blue dashed line is uncorrected. N value at 70° SZA is corrected using zenith sky cloud detector data (red line).

Figure 4. Stray light correction at Boulder.

Figure 5. Stray light correction relation between the solar zenith angle, station pressure, and total ozone.

Comparison case study

Figure 6. Comparison with Umkehr and other measured profiles at Boulder and Lauder.

Results

Figure 7. (Top panel): Time series (time-day average) of the MLS (red) and OMPS (blue) Boulder and MLO station overpass ozone profile data integrated into Umkehr layers 6, 4, and 2. (Right panel): Also shown are MLS and OMPS data smoothed with Umkehr AK (dashed lines) at Boulder, MLO, and the satellites are the results of a match in less than 24 hours.

Figure 8. Shown are differences between Umkehr, OMPS and MLS data selected for two periods (from 2012 to July 2016 and from 2004 to 2011). Comparisons between Umkehr and satellite overpass profiles are shown for MLS (left) and Boulder (middle). The difference between OMPS and MLS profiles over 2012-2016 is shown in the right panel, including effect of the Umkehr AK-smoothing.

Summary and discussion

• Stray light correction of Umkehr is not included in the inter-comparison results (Figure 6, 7, and 8).
• UMK and MLS pass show good agreement (less than 9%) above 30 hPa.
• UMK and OMPS show good agreement in the troposphere and the stratosphere (below 4 hPa).
• OMPS ozone values above 4 hPa are biased high relative to MLS and Umkehr.

Table 1. As in Figure 8. Results are the average from 2012 to July 2016 in the Boulder and Mauna Loa.

<table>
<thead>
<tr>
<th>Pressure [hPa]</th>
<th>Bottom</th>
<th>Top Layer</th>
<th>MLS-OMPS</th>
<th>MLS-UMK</th>
<th>OMPS-UMK</th>
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References