Improvement to ozone profiles derived from measurements of the Umkehr effect by correcting for instrumental stray light.

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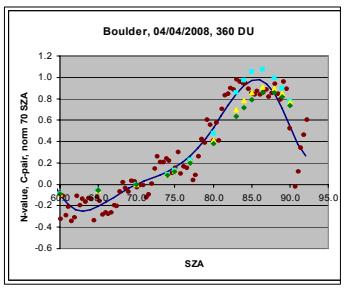
Abstract. The technique for producing a vertical ozone profile by ground-based observations of the Umkehr effect is well known. However, observations of the Umkehr effect by co-located Dobson spectrophotometers yield slightly different results, which are dependent on total ozone values. These differences make it difficult to compare ozone profiles between stations, or to use for trend analysis. Statistical methods can be used to adjust measurements of a specific instrument to those of a reference instrument and produce more coherent data sets, but they fail to explain the cause of the differences. They also require intercomparisons at various total ozone amounts to define the parameters. Our recent investigations suggest that differences are due to the effects of stray light within the instruments and can be corrected by including a stray light parameter in each Dobson instrument's characterization. Here we present some resulting changes to retrieved ozone profiles along with their implications for observational methods, and for completeness of the existing data sets. There is negligible effect of stray-light correction with respect to Umkehr-derived stratospheric ozone trends.

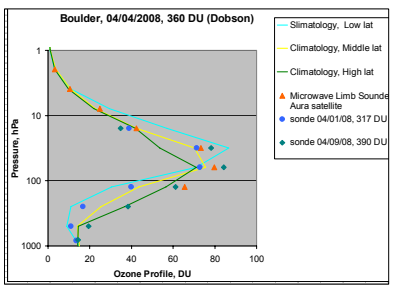
Stray light issues

- Instrument design (filters, gratings, PMT, etc.) limits the spectrum of the measured light.
- Spectral sensitivity across the optical channel is defined by the slit function, which consists of the core, near-field and far-filed stray light.
- Under strong atmospheric light attenuation (large ozone column, low sun elevation), contribution of the stray light to the slit-defined measured light becomes significant, especially in the ozone sensitive channels
- The operational Umkehr retrieval algorithm does not account for the stray light (Figure 1a)
- Retrieved ozone profile has instrument specific errors (Figure 1 c)

Measurements of the stray light in Dobson and its effect on Umkehr RT ozone

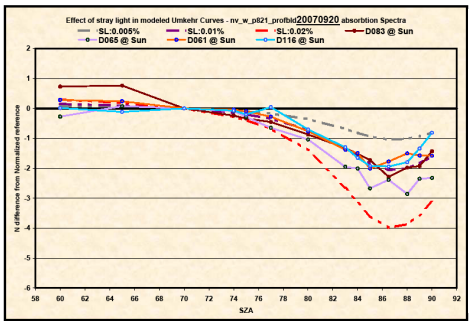
- Stray light in Db 065 was **measured** on April 4 2008 (see more details in R. Evans poster)
- Simulation of the stray light for 360 DU using typical **low**, **middle** and **high** latitude ozone profiles
- Simulations done with and without stray light at 1e-5 level
- Simulations follow closely the measured effect





Comparisons of Brewer/Dobson ozone profile retrievals taken in Boulder on September 20, 2007 and stray light evaluation

- The same day ozone-sonde, MLS data are +/-5 degrees latitude coincidence.
- Ozone sonde below 16 mb (Layer 1-5), MLS above
- TOMRAD RT-code to simulate spectrally resolved zenith sky radiance between 300 and 440 nm.
- Nominal band pass for Dobson and Brewer or extended band-pass to account for stray light
- Brewer Umkehr routine data collected by the NEUBrew network in Boulder, CO
- Martin Stanek PC software (O3BUmkehr) is used to retrieved daily Brewer ozone profiles.



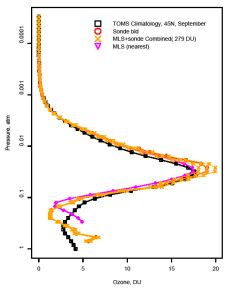
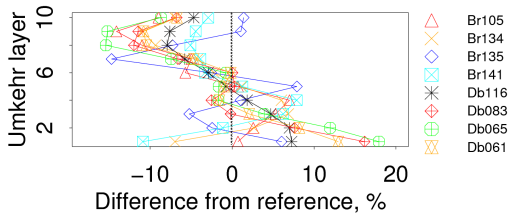


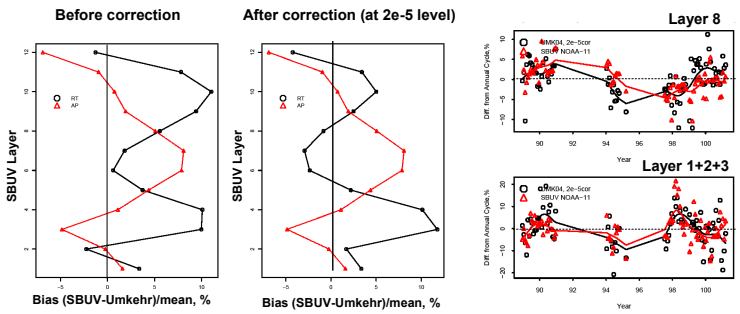
Figure 1a (above, left). Comparison of several Dobson Umkehr synchronized measurements during Dobson intercomparisons at Boulder, CO, USA, on September 20, 2007. A reference Umkehr measurement is simulated based on combination of the ozone-sonde (Boulder, 40 N) and Microwave Limb Sounder (MLS) Boulder overpass ozone profiles. The stray light curves are also shown for comparisons.

Figure 1b (above, right). Total Ozone Mapping Spectrometer (TOMS) standard ozone profile for middle latitudes, Boulder ozone sonde, MLS, and combined profiles are shown as function of atmospheric pressure.

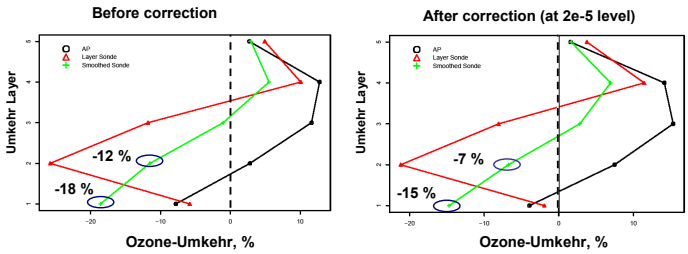
Figure 1c (below). Errors in the retrieved ozone for NOAA Dobson (Db) and NUEBrew (NOAA/EPA UV Brewer network) Brewer (Br) instruments in Boulder, CO, USA. Retrieval errors are associated with uncorrected stray light contribution in Dobson and Brewer measurements.



Comparisons between SBUV NOAA-11 and Umkehr in Boulder (1988-2001) before and after stray light correction, AP difference is also included



Comparisons between ozone-sonde (layer-integrated and AK-smoothed) and Umkehr ozone profiles in Boulder (1985-2005) before and after stray light correction. A difference between the Umkehr a priori (AP) and sonde profile is also included.



Summary of Results

- The stray light synthetic correction seems to influence Umkehr retrieved profiles. Comparisons against sounding in Boulder indicate some improvement in the Umkehr retrieved tropospheric ozone.
- More measurements to verify these results, and to streamline and standardize the process. How can this be done with out intensive modification of instruments.
- Evaluate other methods of measurement of stray light.
- Evaluate the other instrument parameter errors (wavelength selection, band-pass errors, wedge calibration errors, etc) in a similar manner.
- Evaluate Brewer instrument results in a similar manner.

Continuing research

- **If the individual scattered light amount can be measured, then that information can be made an instrumental parameter to be incorporated into the algorithms used to process the data from the instruments.**
- Assess ozone profile retrieval error due to stray light.
- Continue analysis of sounding measurements as validation of Umkehr technique.

See related poster by R. Evans et al. "Measurement of Internal Stray light within Dobson Ozone spectrophotometers".