1. Introduction.

NOAA Dobson Umkehr ozone profile records have been collected since the 1970s. Umkehr ozone profiles are used to monitor stratospheric ozone recovery predicted to occur by the 2050s. Current operational Dobson Umkehr profile algorithms produce data that have uncertainty on the order of ~5% in the stratosphere. However, when large volcanic eruptions inject aerosols into the stratosphere, the errors can be as large as 70%. In order to evaluate Umkehr records for aerosol-related and instrumental artifacts, we compare observations with a hindcast simulation of the NASA MERRA-2 Global Modeling Initiative (GMI) Replay (M2GMI, Orbe et al., 2017; Wargan et al., 2018) and a Chemistry Transport Model (GMI CTM, Strahan et al., 2013, Strahan et al., 2016). The biases found between the models and observations are summarized for each Dobson calibration and volcanic eruption period, thus providing a reference tool for homogenization of the Umkehr time series and removal of volcanic aerosol errors.

2. N-value correction optimized using the M2GMI simulation.

Umkehr measurements are made by tracking relative differences in zenith sky intensities from two UV wavelengths between the horizon and 70 degrees solar zenith angle (SZA). The observed zenith sky intensities are converted to N-values, 100\log(\frac{I_{70}}{I_{horiz}}). Large difference between the observed and modeled N-values are found in the volcanic eruption periods (1982-1984, 1991-1994). Modeled corrections are based on M2GMI model ozone profile data matched to the Umkehr observations.


Validation of optimized Umkehr RT.

The optimized Umkehr ozone processing includes multiple N-value adjustments for each of instrument calibration periods as shown in Figure 4 where arrows at the bottom indicate dates of the applied corrections and during volcanic eruptions shown as yellow colored periods. The changes in the Umkehr Boulder record are assessed through comparisons to M2GMI, GMI CTM, and several satellite datasets (Aurora MLS aggregated SBUV series and JPS OMP5 V5P). Figure 4 also shows comparisons of optimized Umkehr data and the M2GMI model where seasonal to sub-seasonal biases are +/-2% and the long-term mean bias is 0%. Figure 5 shows comparisons with other datasets.

4. Summary and Discussion

Findings

- Umkehr mean bias is reduced after optimization (Figs. 6 & 7).
- Seasonal biases are present and need to be investigated (Fig. 6).
- Mean bias of 5% is found between M2GMI and GMI CTM in the stratosphere (Fig. 5a & Fig. 7).
- Very similar models (MERRA2 and FTIR) have been used.
- Optimized Umkehr (blue) and M2GMI (red) data are shown as monthly averages. Difference between Optimized and Operational Umkehr data is shown as a dark green line. The percent difference between optimized Umkehr and M2GMI model is shown as a light green line. The arrows at the bottom indicate dates of Dobson calibrations and instrument replacements.

Optimized comparisons between Umkehr, MLS, and Aura MLS (2004-2018) show strong dependence on SZA and pressure. The seasonal biases between the Umkehr Boulder record and the Aura MLS data are shown as a dark green line. The percent difference between umb and M2GMI model is shown as a light green line. The arrows at the bottom indicate dates of Dobson calibrations and instrument replacements.

Optimized corrections for volcanic aerosols (Fig. 7) are shown as a dark green line. The percent difference between umb and M2GMI model is shown as a light green line. The arrows at the bottom indicate dates of Dobson calibrations and instrument replacements.

Optimized corrections for volcanic aerosols (Fig. 7) are shown as a dark green line. The percent difference between umb and M2GMI model is shown as a light green line. The arrows at the bottom indicate dates of Dobson calibrations and instrument replacements.

Optimized corrections for volcanic aerosols (Fig. 7) are shown as a dark green line. The percent difference between umb and M2GMI model is shown as a light green line. The arrows at the bottom indicate dates of Dobson calibrations and instrument replacements.

Optimized corrections for volcanic aerosols (Fig. 7) are shown as a dark green line. The percent difference between umb and M2GMI model is shown as a light green line. The arrows at the bottom indicate dates of Dobson calibrations and instrument replacements.