Bias in Dobson Total Ozone Measurements at High Latitudes because of Approximations in Calculations of Ozone Absorption Coefficients and Airmass

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The Dobson spectrophotometer is the primary standard instrument for ground-based measurements of total column ozone. The accuracy of its data depends on the knowledge of ozone absorption coefficients used for data reduction. We document an error in the calculations that led to the set of absorption coefficients currently recommended by the World Meteorological Organization (WMO). This error has little effect because an empirical adjustment was applied to the original calculations before the coefficients were adopted by WMO. We provide evidence that this adjustment was physically sound. The coefficients recommended by WMO are applied in the Dobson network without correction for the temperature dependence of the ozone absorption cross sections. Based on data measured by Dobson instruments 80 and 82, which were operated by CMDL at the South Pole, we find that omission of temperature corrections may lead to systematic errors in Dobson ozone data of up to 4% (Figure 1). The standard Dobson ozone retrieval method further assumes that the ozone layer is located at a fixed height. This approximation leads to errors in airmass calculations that are particularly relevant at high latitudes where ozone measurements are performed at large solar zenith angles (SZA). At the South Pole, systematic errors caused by this approximation may exceed 2% for SZAs larger than 80°. The bias is largest when the vertical ozone distribution is distorted by the "ozone hole" and may lead to underestimation of total ozone by 4% at SZA = 85° (airmass 9). Dobson measurements at the South Pole were compared with ozone data from a collocated SUV-100 UV spectroradiometer and Version 8 overpass data from National Aeronautics and Space Administration's Total Ozone Mapping Spectrometer (TOMS). Uncorrected Dobson ozone values tend to be lower than data from the two other instruments when total ozone is below 170 Dobson Units or SZAs are larger than 80°. When Dobson measurements are corrected for the temperature dependence of the ozone absorption cross section and accurate airmass calculations are implemented, data from the three instruments agree with each other to within ±2% on average and show no significant dependence on SZA or total ozone.

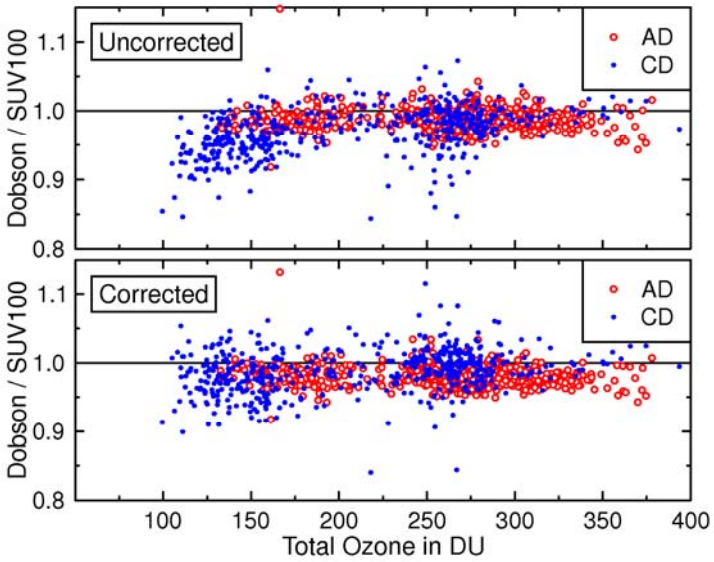

Figure 1 (Top). Ratio of uncorrected (i.e., original) Dobson total column ozone to ozone data calculated from measurements of a SUV-100 UV spectroradiometer. The SUV-100 instrument is part of the National Science Foundation's Office of Polar Programs UV monitoring network. Dobson and SUV-100 instruments are located in the Atmospheric Research Observatory at the South Pole.

(Bottom) Ratio of corrected Dobson total ozone data and SUV-100 data. Dobson data have been corrected for the temperature dependence of the ozone absorption cross section and for systematic errors that are caused by approximations in airmass calculations implemented in the standard Dobson data reduction scheme.