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Updates to the zenith-sky ozone retrieval algorithm for the Brewer spectrophotometer

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The Brewer spectrophotometer estimates the ozone content in the atmosphere from measurements of ultraviolet (UV) solar radiation in two different observation modes. In the direct sun (DS) geometry, which is the primary measurement mode, the Brewer directly points to the sun. This technique guarantees very high precision and accuracy and is equally sensitive to stratospheric and tropospheric fractions of the total ozone. In the zenith sky (ZS) geometry, the Brewer points to the zenith and records the polarised components of the scattered radiation reaching the ground from this direction. In the ZS mode, the path of the solar radiation through the stratospheric ozone layer is enhanced. ZS observations are very useful when the sun is low on the horizon (e.g., at high latitudes) or when direct sun measurements are not possible (e.g., at mountain valley sites during winter, when the sun is not visible). Moreover, ZS estimates are considered to be less affected by the presence of clouds than DS, thus allowing to compare satellite and ground-based instruments in cloudy scenarios and to generate long-term ozone time series unbiased by meteorological conditions.

The algorithm to retrieve ozone from zenith measurements was first developed by Dobson (1957) and is based on the so-called "zenith sky charts", i.e. empirical functions describing the relation between the zenith radiance and the ozone content. Such polynomials are determined through comparison between DS and ZS observations. Fioletov et al. (2011) updated this method on the basis of radiative transfer models (RTMs) and comparison between DS and ZS measurements. Using this technique, they effectively reduced the degrees of freedom (calibration coefficients) from 9 to 2.

In the present contribution, we propose a new method fully relying on a formal description of the real physics of ZS observations and radiative transfer models (including polarisation) rather than on empirical (polynomial) relations. The technique is additionally able to separate instrumental and atmospheric effects. Moreover, the method is completely independent from DS measurements and, therefore, provide a way to auto-calibrate the instruments through the Langley extrapolation technique at pristine sites. The results of a 15-days calibration campaign at Mauna Loa Observatory (MLO), Hawaii in September-October 2015, organised to test the new method, are reported. We describe the issues that arise from the very strong ozone absorption in the UV spectral range and the techniques to overcome them.