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Aerosol optical properties and their effect on the UV solar irradiance at Uccle, Belgium

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Aerosols are a major influence in the Earth's energy balance, affecting the incoming solar radiation by scattering and absorption. The effects of aerosols are of high uncertainty due to their spatial and temporal variability. Additionally, the great majority of studies are mainly focused on the visible part of the spectrum. However, the effects in the ultraviolet (UV) irradiance are of extreme importance, because of the role that this part of the spectrum has in living organisms. In this study, the effect of aerosols on UV irradiance reaching the ground and the derived single scattering albedo are examined at Uccle, Belgium from July 2006 until May 2010.

Total ozone column, UV irradiance and aerosol optical depth (AOD) are measured on a daily basis from the Brewer#178 instrument at Uccle. AOD measurements from a collocated Cimel sunphotometer, part of the Aerosol Robotic Network (AERONET) are also provided. To avoid cloud contamination, only quasi-simultaneous measurements from the two instruments are processed, based on the fact that the Cimel data are already cloud-screened.

The UV measurements are provided in the range 290 - 363 nm with a 0.05 nm step and are corrected for the cosine effect. AOD is derived at Uccle from Brewer's direct sun observations, using the Langley Plot Method. It is provided in five wavelengths, 306.3, 310.1, 313.5, 316.8 and 320.1 nm.

Calculations with the radiative transfer code UVSPEC (LibRadtran package) are used in order to estimate the aerosol effect on irradiance. The aerosol radiative forcing efficiency (RFE) is calculated in the 300 – 360 nm wavelength range from the integral of the Brewer measurements and the modeled irradiances at 300 – 360 nm, under aerosol free conditions. RFE is the change in irradiance due to aerosols per unit of AOD and ranges from -26.26 to -22.89% per unit of AOD, depending on the solar zenith angle at the time of the measurement.

Another set of theoretical calculations is performed with UVSPEC to estimate the single scattering albedo (SSA) of aerosols at five wavelengths close to those of AOD measurements (306.5, 310, 313.5, 316.5 and 320 nm). An SSA value is accepted when the measured and modeled irradiances agree within 1%. The monthly mean values of SSA are estimated, along with the standard deviation, at each wavelength and are qualitatively compared with the Cimel SSA at 440 nm. The agreement is better as the wavelength increases due to the lower dependence on ozone variations. The estimated SSA monthly values from the Brewer data range from 0.84 in October to 0.97 in August. The accuracy of the method depends on the aerosol load and the solar zenith angle at the time of the measurement and is higher for high AOD values.