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Wavelength dependence of diffuse and total Cloud Modification Factors for UV irradiance and actinic flux for different cloud optical and microphysical properties

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Measurements of UV irradiance and actinic flux spectra, cloud cover, optical thickness (COT), liquid water path (LWP), effective radius (reff), and height are used, together with radiative transfer simulations, to investigate the influence of clouds on the spectral UV solar radiation. The cloud modification factors (CMF) for the total and for the diffuse components in overcast conditions are used. The observations were made during a 2-month measurement campaign carried out in May and June 2010 at the Trisaia Research Centre (40.16ºN, 16.64ºE, 40 m a.s.l.), in Southern Italy.

An Ultraviolet Multifilter Rotating Shadowband Radiometer (UV-MFRSR) measured solar irradiance at seven narrowband channels (central wavelengths at 299.0, 304.7, 310.7, 316.8, 323.7, 331.7, and 367.2 nm; each channel with about 2 nm Full Width at Half Maximum, FWHM, bandwidth). The shadowband enables the instrument to measure two components of the solar irradiance -total horizontal and diffuse- and to simultaneously derive the direct normal contribution. Downward spectral actinic fluxes were measured using a METCON diode array spectrometer (DAS), which measures radiation between 280 and 700 nm with a FWHM bandwidth of about 2.5 nm at 0.83 nm steps. A HATPRO (Humidity And Temperature PROfiler) microwave radiometer allowed to derive the cloud LWP. The effective radius of the cloud particles could be obtained from a visible MFRSR (6 channels at 415, 500, 615, 673, 870, and 940 nm, nominal wavelengths, each with 10 nm FWHM bandwidths; plus one photodiode covering the 300-1040 nm spectral range) measurements. The cloud base height was measured by an infrared camera.

Visual observations of cloud cover are used together with 2 different automatic algorithms to identify overcast conditions (8 octas), selected for the analysis.

The CMF for irradiance and actinic flux show different wavelength dependencies: the total spectral irradiance in the UV shows little dependence on solar zenith angle (SZA), while the spectral actinic flux in the same range presents a stronger dependency on SZA. For example, for a fixed value of COT of 15, the spectral CMF for irradiances at wavelengths > 320 nm ranges between 0.5 and 0.4 for SZAs in the interval 20-65º; while the spectral CMF of the actinic flux varies from 0.7 at SZA = 20° to about 0.3 for SZA = 70º in the same wavelength range.

The CMF of the diffuse solar irradiance increases with wavelength; the increase depends on SZA, with CMF > 1 for COT = 15 and SZA < 40º.

The CMF displays a strong dependency on LWP and on the cloud particles effective radius. For example, for a LWP of 0.1 kg m-2 and 17º < SZA < 20º, the CMF for the diffuse irradiance at 304.7 nm varies between 0.6 for reff = 5 μm, and 1.2 for reff = 15 μm; for the same SZAs the CMF at 367 nm increases to 0.9 (reff = 5 μm) and 2 (reff = 15 μm).

Radiative transfer simulations carried out with the UVSPEC model are in good agreement with the experimental data.