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Influence of the atmosphere on the UV radiation at ground level in a mid-latitude region, Iberian Peninsula

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Complex processes of scattering and absorption control the transmission of solar UV radiation through the atmosphere, being the surface levels significantly affected by ozone, clouds and aerosols. The importance of these three factors varies with the characteristics of the atmosphere in each region. Thus, this study particularly focuses on the atmospheric effects on surface UV radiation in the Iberian Peninsula, a relevant region in southwestern Europe (36º-44º N).

The strong attenuation of solar UV radiation by the atmosphere is mainly due to its absorption by the stratospheric ozone. This effect is particularly intense for the UV erythemal irradiance (UVER), which can be estimated as 10.3 W/m2 at the top of the atmosphere, and decreases to maximum values at surface of about 0.25 W/m2 (UV Index equal to 10) during summer in the Iberian Peninsula. Total ozone column (TOC) exhibits a marked short-term variability in mid-latitudes, causing a substantial variation in surface UV radiation during cloud-free periods. Thus, our results show that a reduction of 5% in TOC between two consecutive cloudless days may produce an increase of up to 10% in UVER. Additionally, substantial enhancements of surface UV have been reported during extremely low TOC events (named ozone miniholes) in the study region.

The short-term variability of the UV radiation reaching the Earth's surface is mainly controlled by changes in the cloud cover. Thus, cloudiness variability often masks the influence of changes in ozone, and it may reduce, cancel or even reverse the expected UV increase caused by the reduction in TOC. In order to evaluate the cloud effect on UV radiation, we have considered a cloud modification factor (CMF) defined as the ratio between the measured UV radiation in a cloudy sky and the simulated radiation under cloud-free conditions. Typical CMF values vary from 0.3 to 0.9, depending on the cloud type, optical depth, spatial distribution across the sky and solar elevation angle. Clouds may also cause an enhancement effect, evidenced by increased surface UV irradiance (up to 40%) with unblocked solar disk.

Aerosols also have a great impact on the transmission of UV radiation through the atmosphere. We have quantified the aerosol forcing efficiency in the UV erythemal range showing values between −62 and −26 mW/m2 per unit of aerosol optical depth at 380 nm. This variable is strongly affected by changes in the size and absorption properties of the particles. Due to its geographical position near African, the Iberian Peninsula is frequently affected by African air masses transporting mineral dust aerosols. According to our results, a large load of these particles can lead to substantial reductions in the surface UV irradiance (up to 50% with respect to low aerosol load conditions).

All these results highlight the different roles that ozone, clouds and aerosols play modulating the surface UV radiation. In most cases, these three factors act synergistically, being their individual evaluation a challenging task. Therefore, it is essential to maintain routinely operative ground-based stations with high-quality instrumentation to determine the influence of the diverse atmospheric factors on the surface UV radiation in different regions worldwide.