Dear authors,

I have read the reviewer comments and the answers. To my point of view the paper still has a number of major methodological issues and also issues on describing the assumptions made in this work in order to end up in the conclusions.

Dear Editor, we submit a new version of this study answering to many of your questions. Firstly, we implemented the dataset including measurements at 340 nm and extending the period under study up to 2020 and no more 2016. Secondly, we re-analyzed the dataset with a new code: Skyrad_MRIv2. pack (Kudo et al., 2021) to retrieve the aerosol optical properties from the sun-sky radiometer measurements. The use of a new computer code, more accurate in retrieving the wavelength dependence of SSA, allowed us to obtain better results. Finally, the structure has been slightly modified with the following sections: 1 Introduction; 2 data; 2.1Measurements site; 2.2 Sun-sky radiometer measurements; 2.3 Brewer measurements; 2.4 Particulate Matter samples collected at the surface. 3 Methodology; 3.1 Sun-sky radiometer retrieval method; 3.2 Brewer retrieval method; 3.3 PM samples chemical analysis; 3.4 Optical properties of surface aerosol from a radiative transfer model; 3.5 Assessment of the dependence of UVI on the aerosol optical properties; 4 Results; Validation of the method to extrapolate the aerosol properties to 340 nm; 4.2 UVI dependence on aerosol optical parameters; 5 Conclusions.

Major aspects

The work has a major disadvantage. It tries to describe the effect of aerosol properties in the UV Index not having any aerosol properties measured at this region.

We implemented the dataset including measurements at 340 nm and extending the period under study.We re-analyzed the dataset with a new code: Skyrad_MRIv2. pack (Kudo et al., 2021) to retrieve the aerosol optical properties from the sun-sky radiometer measurements. In order to relate the UVI to the aerosol optical properties, these latter were determined at the 340 nm. Measurements at this wavelength were started in 2016 ("dataset 2"), while the shortest wavelength was 400 nm prior to that date ("dataset 1"). Hence, to increase the length of the aerosol dataset at the shortest measured wavelength and cover a larger overlapping period with the UVI series from the Brewer, we developed a new physically-based method to extrapolate the aerosol optical depth and aerosol properties from longer wavelengths (400 nm and above) down to 340 nm for both dataset 1 and 2, using the Aerosol Optical Properties (AOP) program included in the Skyrad MRIv2 package. Then, to assess the accuracy of the method, we compared the outcome of this extrapolation with the retrieval obtained using all available wavelengths, including 340 nm (period dataset 2). Based on the very good results of such a comparison (Sect. 4.1), we always used the extrapolated data in the entire analyzed period for consistency. Replacing the retrievals based on observations at 340 nm with the extrapolation is therefore not expected to affect the findings of this study.

So in order to end to the current conclusions there are the following assumptions:

- Ang. Exp derived from 400-500 range is accurately describing AOD at 305-315nm which is the effective (or the most important) wavelength range for UVI. This can not be true as the introduced uncertainty is aerosol type dependent

We now used Angstrom exponent calculated between 340 and 500 nm

- SSA in the visible range is equal or proportional with the one at UVB range for all aerosol types. It is mentioned in the introduction that SSA spectral dependence is depending on the aerosol type

  We now used SSA calculated at 340 nm. The use aerosol optical properties determined at a "measured" wavelength as close as possible to the one corresponding to the maximum of the erythemally-weighted solar spectrum (usually <320 nm, depending on the solar zenith angle) is necessary, in order to have the possibility to validate the retrievals as shown in the new section 4.1.

- PM10 analysis ("In fact, assuming that the in situ measurements are representative of the entire column,..."). Based on the text and fig. 3 this is difficult to assume as there are a number of dust cases where is commonly known that aerosols can be found a lot heigher than the surface.

The sentence has been removed and the use of the results from URBS campaign has been reviewed.

These three issues have to be re-discussed and relevant uncertainties and discussion has to be included.

The expected uncertainty in the retrieval products at near-ultraviolet, visible, and near-infrared wavelengths is less than 0.04 for AOD, and less than 0.05 for SSA, as discussed in the paper Kudo et al., 2021).

Authors correlated UVI with AExp, AOD and SSA separately. Maybe it is a way to face the difficulties risen from the previous mentioned comment. But in general. If SSA measurements are available UV changes are proportional to AOD* (1-SSA). However, the spectral dependence of SSA is obviously affecting the results here.

We estimated $AAOD_{340}$ and its dependence on UVI is now shown in the text

An example:

Figure 9a slope = -1.77 and Figure 9b slope = -2.96. That shows that for a unit of aerosol optical depth the decrease of UV index in an absorbing (at visible range) environment (fig. 9a SSA<0.85) is less than the one with less absorption (fig 9b SSA>0.85). Even combined with the intercepts fig 9a reports a ~25% reduction of UVI per unit of AOD and fig 9b a ~36% reduction per unit of AOD.

Is this possible ? Possibly it means SSA spectral dependence affects this analysis. And this SSA spectral dependence also probably linked with AOD (through different aerosol types). Something that also Bais et al., 2005 (Effects of aerosol optical depth and single scattering albedo on surface UV irradiance". Atmospheric Environment, 39, 1093-1102, 2005) has shown. Same is valid for figures 9c and 9d. Still lower SSA cases (9c) are linked with smaller UV changes for the same (a unit) of AOD and also theoretically larger air masses (θ=40) should be linked with higher UV changes for the same AOD and SSA due the increased path of the atmosphere where the UV attenuates due to aerosols.
The use of a new computer code, Skyrad_MRIv2, more accurate in the retrieving the wavelength dependence of SSA allowed us to obtain better results.

Other comments

Abstract

"The surface forcing efficiency, provided by the decreasing trend of UV index with AOD, which is the primary parameter affecting the surface irradiance during clear sky conditions in Rome, was found very significant, probably masking the dependence of UV index on SSA and Ångström exponents."

In general, to quantify the effect of AOD, and SSA separately you need to keep one of the constant especially here that they are interconnected.
The use of the new computer code, Skyrad_MRIv2, allowed us to obtain more accurate results.

Theoretically the effect of AExp in UV here is just the effect of extrapolating correctly from the visible to the UV range.
We now used Angstrom exponent calculated between 340 and 500 nm

"Moreover it was found greater for larger particles and with a more pronounced slope at the smaller solar zenith angle." I can not understand this sentence.

The description of the results has been strongly modified thanks to the new processing code and the availability of the new shorter wavelength measurements. The surface forcing efficiency showed that AOD is the primary parameter affecting the surface irradiance under clear sky conditions in Rome. SSA and the Ångström exponent are also identified as secondary influencing factors, i.e., the surface forcing efficiency is found to be greater for smaller zenith angles and for larger and more absorbing particles in the UV range (such as, e.g., mineral dust).

Introduction

"because in this wavelength region the columnar absorbing and scattering properties of suspended particles are not deeply inspected as in the visible spectral range."

I would suggest "because aerosol absorption properties in the UV are more difficult to be determined compared with the visible range"
The sentence has been changed, keeping the suggested meaning but with different words.

(SSA), that change to (SSA) that Optical depth (AOD) -> aerosol optical depth (AOD)
Aerosol optical depth = AOD , single scattering albedo = SSA from then on to the whole document.
We are sorry but we didn't understand this comment

Especially in winter - (I think in all seasons)

"di Sarra et al. (2002), Panicker et al. (2009), and Antón et al. (2011), among others, have shown that an increase of AOD induces a reduction of the UV index (UVI), an effective parameter to quantify the potentially harmful effects of UV radiation."

I do not understand this paragraph. Increase of AOD will lead to a UV decrease this is trivial. But how much it depends on other parameters and also by the use of AOD at UV wavelengths and not in 400nm.
The use aerosol optical properties determined at a "measured" wavelength as close as possible to the one corresponding to the maximum of the erythemally-weighted solar spectrum (usually <320 nm, depending on the solar zenith angle) is necessary, in order to have the possibility to validate the the retrievals as shown in the new section 4.1. In our case the shortest is now changed to 340nm and the dependence of UVI on aerosol properties at this wavelength has been studied.

An effective aerosol related parameter not related with AOD but more with SSA and other aerosol optical properties can be defined as the aerosol radiative forcing efficiency (RFE) (e.g. see Kazadzis et al, 2009 (www.ann- geophys.net/27/2515/2009/). There is also a report there on how SSA can affect the RFE in an environment with much similarities as Rome. Aerosol PREDE/POM measurements. You need to describe the aerosol properties you use in this study (AOD, SSA, Ang. Exponent) of which wavelengths and what is the uncertainty of these measurements.

The expected uncertainty in the retrieval products at near-ultraviolet, visible, and near-infrared wavelengths is less than 0.04 for AOD, and less than 0.05 for SSA, as discussed in the paper Kudo et al., 2021). This has been added in the text.

"For sza>40, as in wintertime", I think For sxa>40 is enough as straylight and cosine effects mentioned here are only related with SZA and not seasons.

"as in wintertime" was removed

The performance of the Brewer instrument for UV measurements was controlled every two years till 2014 through intercomparisons to the traveling reference QASUME UV spectroradiometer (Groebner et al., Applied Optics, 44 (25) 2005). I would also propose to put this paragraph starting "the performance of the Brewer ...till ... Sianni et al., 2013)" in the end of this section after ..extrapolation"

The text is in a new structure

SHICRIVM algorithm needs a reference

The reference is added

The elastic LIDAR ... days affected by dust" . How ? (reference or text). Methodology

This part has been removed

"To point out the possible effect of aerosol optical characteristics measured at 400 nm on UVI*, AOD400, SSA400, Ang and Ang400-500 were analyzed as function of UVI* at the two fixed solar zenith angles, taking estimations of aerosol parameters and UVI* within ±5 minutes."

As said this is my main concern for this paper. The representativeness of aerosol properties in the UV solely by measurements in the visible.

Now we moved the analysis to the 340 nm.

AERONET and Skynet comparison: I think this paragraph is confusing. On the one hand when results agree, authors conclude that results are within the Skynet standard deviations (this also should be replaced by Skynet uncertainty), but for March and May the authors refer to spatial issues due to the non collocation of the instruments

This part is no more in the new text

"In fact, assuming that the in situ measurements are representative of the entire column,..." How can this be possible when there are a number of dust events (fig 3) that in general affect much more the columnar properties due to the presence of aerosol plumes higher in the atmosphere ? "The general behavior of observed five micro sources.. has been assumed not substantially changed in the last years". This is difficult to assume looking at the SSA variability for the 7 year period on fig. 1 and the text: "SSA400 vary between a minimum value of 0.84±0.08 (observed in 2016) and a maximum of 0.97±0.03 (observed in 2015)." This is a huge change in absorption that for sure has to do with changes in the aerosol type composition in the atmosphere.

The use of the results from URBS campaign has been reviewed.