

Anonymous Referee #3

General comments:

The manuscript describes the aerosol optical characteristics in the urban area of Rome for the time period 2010-2016. The impact of aerosol single scattering albedo, aerosol optical depth and Ångström component on the UV index are analyzed. Chemical characterization of urban PM10 samples from a field campaign was performed, and the contribution of main macro-sources was evaluated. The data set is analyzed for the first time and this kind of analyses of aerosol optical characteristics in the urban area of Rome is novel.

Specific comments:

Major comments: You write in the abstract that “PM macro-components were grouped in order to evaluate the contribution of the main macro-sources (SOIL, SEA, SECONDARY INORGANIC, ORGANICS and TRAFFIC) and the analysis of the modulation of their concentration was found to strongly affects the absorption capability of the atmosphere over Rome.” However, I don’t find clearly explained in the Results Chapter of the manuscript the statement “the analysis of the modulation of their concentration was found to strongly affects the absorption capability of the atmosphere over Rome.” Please explain more clearly the connection between the PM macro-components and the absorption capability of the atmosphere over Rome. From the Results I mostly understand from page 10, lines 285-286, that “Scatter plot of SSA400 versus the SOIL component (Figure4) shows a slight negative correlation ($R = -0.54$), whereas no other correlation is visible for the other components and other optical and physical parameters. “ In case it is related to the theoretical calculations of page 8, lines 260-265, please explain in more details in Methodology how you have used the model.

The sentence in the abstract about the impact of the main macro-sources concentration on the absorption capability of the atmosphere over Rome was inferred from the theoretical calculations performed by the Rstar model, and not from the results related to the analysis of the ground based measurements. This is because, as also written in the text, columnar absorption properties and in situ measurements may not provide correlated information. Therefore, we agree with the observation of the Reviewer and we changed the sentence in the abstract as: “The modulation of their concentration, according to theoretical calculations, is expected to strongly affect the absorption capability of the atmosphere over Rome”.

We also added the following paragraph in the Methodology section explain how the model has been qualitatively used: “ Finally to help the understanding of the possible different effects of PM10 macro-components concentration on the atmosphere over Rome, the imaginary parts of refractive index of each fundamental materials in the Rstar model, were taken as reference. Rstar is a radiative transfer model (Nakajima and Tanaka 1986) able to simulate the radiation fields in the atmosphere-land-ocean system at the wavelength range 0.17 – 1000 μm . Eight fundamental materials (water, dust-like, sea salt, volcanic ash, yellow sands, ice, water-soluble, soot and 75% H_2SO_4) are considered to assemble a three component internal mixture for each of the ten particles model types (Water, dust-like, volcanic-ash, rural, urban, yellow sand, ice, soot, 75% H_2SO_4 , sea spray, tropo). In this study the refractive indexes for sea salt, soot and dust-like fundamental materials were taken as reference”.

Add to the methodology the use of Lidar for detection of Sahara dust events.

The following sentence has been added in the Metodology section: “During the same campaign, the presence of Saharan dust over Rome was detected by manually inspecting the Lidar Backscatter ratio at 532 nm. Days showing aerosol above the Boundary layer, and the simultaneously check of the Hysplit (Draxler et al., 1998) back-trajectories (bringing air mass from Saharah reagions), were classified as “dusty””.

Minor comments:

Abstract Page 1 L28: “...is the primary parameter affecting the surface irradiance. ...”. Please specify that it is for clear sky at Rome. In some other sites, total ozone can be the primary parameter for clear skies. And if not clear skies, then cloudiness has an important role.

DONE

Page 1, line 38. Can you specify why the aerosol influence on UV is still uncertain.

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

Page 4, lines 108-111, Why is this mentioned here, if UVI used in the study is calculated using SHICRIVM? I suggest to remove those line.

The sentence has been reformulated as follow: "The SHICrivism algorithm, used to obtain the biologically effective UV irradiance, as explained in the section 3, compensates for the missing contribution of wavelengths longer than 325 nm. Based on considerations for similar corrections in the Brewer operating software (Fioletov et al., 2004), we estimate an uncertainty <2% in the UV index value for solar zenith angles <70° due to this extrapolation."

Page 5, lines 142-148, for people who are not familiar with cloud screening of aerosol measurements, the explanation is not clear. Please reformulate the reason for rejecting SSAs lower than 0.70.

The sentence has been reformulated as follow: "The simulation of an atmosphere contaminated by both dust-like and water insoluble aerosols brought to SSA400 values of about 0.70. Simultaneously values varying between 0.71-0.75 were retrieved testing a cirrus contamination case by enhancing the coarse mode for simulating the presence of ice particle types (cirrus particles model of the World Climate Programme report, Deepak and Gerber, 1983). Following these results, SSA400 values lower than 0.70 were rejected in this study because considered unrealistic, but it should be taken into account that values between 0.71 and 0.75 could contain information on both dust presence and cirrus-cloud contamination."

Page 5, line 158, Which are the highest UVI values (give some numbers).

The following sentence has been added "(a peak of 12.3 at Plateau Rosà, 3500 m a.s.l., in Valle d'Aosta Region, Italy)"

Page 5, line 159, How the clear sky spectra were selected?

They are selected according to : Alexandrov, M. D., A. Marshak, B. Cairns, A. A.Lacis, and B. E. Carlson (2004), Automated cloud screening algorithm for MFRSR data, Geophys. Res. Lett., 31, L04118,doi:10.1029/2003GL019105

The reference has been added in the text

Page 7, lines 224-225. It would be good to show the AERONET data also for the other years. Then it would be easier to the agreement/disagreement between the two instruments.

The comparison for the entire period has been shown, Figure 1 updated, and a Reference (Di Ianni et al., 2018) has been added.

Page 7, lines 225-226, Please move the AERONET explanation into the Section Methodology. Including the use of different wavelengths than for POM.

We retain that the use of AERONET retrievals in a different location than the one under study, is not part of the methodologies used in this study. They are merely used to show that the less famous SKYNET products are in good agreement with the AERONET ones therefore, we prefer leave the very short description of AERONET inversion and difference in wavelengths, in the results section.

Page 7, line 230, How did you defined that agreement is significant?

The following sentence has been written: "the agreement between the AERONET and SKYNET properties is mostly within the SKYNET standard deviations".

Page 7, line 235, Monthly averages of the total ozone content values and . . .

The highest Ozone monthly measured values has been added in the text

Page 8, line 236, Please explain which kind of seasonal variability (higher in spring. . .) and give the highest values.

The following sentence has been written: "The seasonal ozone behavior is typical of mid-latitude sites, with highest values measured in spring and particularly in April 2010 (385 D.U.) and March 2016 (374 D.U.).".

Page 8, line 238, I don't see the cumulated precipitation and pressure in the Figure.

Following the suggestion of another reviewer, they have been deleted but we forgot to delete the sentence too. Thanks.

Page 8, line 239, only the SSA400 and UVI is plotted in Figure 2. Not the AOD or Ang.

Corrected

Page 8, line 245, I don't understand the explanation, as aren't the UVI measurements performed under clear skies?

As said in the Methodology : "clear sky conditions (no clouds over the sun) were used to retrieve UV index values". This doesn't exclude the presence of scattered clouds in the sky, but can alter the UVI value. In particular, we may expect that a higher occurrence of scattered clouds conditions, corresponding to lower UVI values passing the cloud screening procedure (no cloud over the sun) , may be associated with periods with high precipitation during short-lived weather spring-summer disturbances.

We slightly changed in this sense the explanation.

Page 9, Figure 1 caption, Explain the red point also in the Figure caption. Add "monthly means" and for UVI at local noon.

Red points explained. "Monthly averages" is used in the text instead of "mean" to avoid the repetition, few words later, with "Annual means". For homogeneity is better leaving "averages" also in the caption. Added at LOCAL NOON for UVI

Page 10, Figure 2, local noon UVI under clear sky?

"Local noon" has been added. Clear sky has not been added, because it is explained in the methodology that only cloud screened values are used (no clouds over the sun)

Page 12, lines 314 and 315: Why not to try to analyse the aerosol absorption optical depth AAOD (1-SSA)*AOD?

As shown in Fig 3, a clear dependence of AOD on UVI is visible, but not on SSA. Therefore, the dependence of AAOD on UVI is expected to be mostly caused by the AOD dependence rather than the SSA one.

Nevertheless, we tried analyzing the Absorption Angstrom exponent (AAE), whose information would have been very interesting. Unfortunately the Skyrad 4.2 pack, used in this study, has no smoothness spectral constraints on refractive indexes, as conversely AERONET and Skyrad-A have (Kudo et al., 2016 doi:10.5194/amt-9-3223-2016). This means that SSA values at 400 nm could be good (as demonstrated by the comparison with AERONET in Figure 1), but the SSA spectral dependence, at the basis of the AAE calculation is not.

Page 12, lines 316-319: What was the criteria for the chosen values to be used to make the division into subgroups?

The values separating the different groups were determined according to the frequency distributions of the two variables for the entire investigation period, shown in Figure 7. This is already stated in the text.

Page 12, line 337: How did you calculate the corresponding change of UVI* to be about 2?

It is from Figure 6, plot of UVI* vs Ang400-500. It has been added in the text

Page 13, line 345: Can you give any reasons why your results differ from those of Anton et al. 2011?

An explanation has been given at the end of section 4.

Page 13, line 354: There is a missing verb in the sentence + add at 30 degree, if so.
corrected

Figures 8 and 9, Move the heading of the color panels on the top of the color panel.
We are sorry but this is not possible because the headings are long and the center of the titles of each plot will be compromised.

Page 16, line 398, Where did you show results of analysis using AOD at 500 nm?
AODs at 400 and 500 nm were used to calculate Ang400-500. It has been explained in the text.

Page 16, line 401-403, Here again, why not to study the AAOD?
Please see the answer to your question above

Page 16, lines 413-415. What supports your assumption that the five macro – sources have not changed in the last years?
Generally, stable conditions exist during summer seasons in Rome characterized by a constant contribution of sea breeze during daytime. The SOIL source represents the most consistent contribution to the PM mass because the more aridity of soil during summer period lead to a higher resuspension of crustal-origin components operated by wind and vehicular traffic (Perrino et al., 2016, INDOOR AIR doi:10.1111/ina.12235). The stability of this situation supports the assumption we did. Many studies have been performed on the chemical analysis of the PM composition, but always related to short periods. In fact, it is impossible studying the PM chemical composition for a period long as the one considered in this study.

And as I wrote in the General Comment, I don't understand what supports the sentence "the variations in the absorption capability of the atmosphere over Rome were attributed to the different absorption characteristics of the macro-components and their modulation of concentration in the atmospheric mixture."

Please see the answer to your question at the beginning of the file.

Technical corrections:

In general the text contains long sentences, which are difficult to follow. Paragraph breaks are missing, e.g. in the section Results.

Paper has been re-read and corrected for long sentences.

Page 5, New paragraph cut between lines 152 and 153.

Done

Same for line 158 before Spectral UV...

Done