Response to Editor's (Stelios Kazadzis) comments

I would like to include here some comments on the revised manuscript.

Page 2, line 14, clouding – clouds
P 2, L31: trends – positive trends
P3 L16: "We will strive to support (or disprove) the hypothesis by comparing the erythemal and UV-A (324 nm) radiation measurements by the BSs in Warsaw and Belsk for the period May 2013-December 2015."
I think this can be eliminated as at this point as you can clearly say if this hypothesis is correct or not.

Answer:

The suggested changes were made.

Page 4 , L2 stray light needs a reference.

Answer:

The following reference was added to the manuscript:
Bais, A. F., Zerefos, C. S., McElroy, C. T.: Solar UVB measurements with the double- and single-monochromator Brewer ozone spectrophotometers, Geophys. Res. Lett., 238, 833–836, doi: 10.1029/96GL00842, 1996.

P4, L28 the same ratio – Which one (wavelengths/erythemal) ?

Answer:

This issue was clarified in the paper, P4, L24-29: "Ratios between erythemal and UV-A (324 nm) doses (...) The same ratios are measured for the period of the Warsaw observations (May 2013 to December 2015) by BS207 and BS064 at Belsk to assess the impact of the urban agglomeration on the erythemal and UV-A radiation."

P5 line 8-13
Since there are other publication that are showing significant differences of UV ssa compared with the visible one especially at urban areas I would suggest to change the paragraph (and remove non used references after that) :
"We used SSA at 440 nm as a constant for the whole ultraviolet spectrum, as it was found that monthly averages estimated from BS at Uccle were in close agreement with the CIMEL measurements at 440 nm, especially for 320 nm (Nikitidou et al., 2013). Furthermore, Liu et al. (1991) performed Mie calculations for the rural aerosol model (Shettle and Fenn, 1979) and suggested that for this type of aerosol, SSA is approximately independent of wavelength. There are no measurements performed for SSA at the UV wavelength range."
To:
Since there are no AERONET related measurements of SSA at UV wavelengths , we used SSA at 440 nm as a constant for the whole ultraviolet spectrum, as it was found that monthly averages estimated from BS at Uccle were in close agreement with the CIMEL measurements at 440 nm, especially for 320 nm (Nikitidou et al., 2013).
Also, because the suggestion here that SSA is independent of wavelength is in contradiction with your discussion hypothesis of SSA can be lower in the UV.

Answer:

The suggested change was made.

P5 line 20 The mean ratio of which wavelength range (eryhthemal)?

Answer:

We meant erythemal doses. It was changed to "The mean value of the ratio between erythemal doses (...)" (P5, L19-20).

P6 line 8 : (local noon - 3h, local noon-0.5h) is not 3 hours.
Answer:

It should be "(local noon -3.5h, local noon -0.5h)" and was corrected.

Figure 8a: AOD ratios are misleading in this case. In addition, absolute AOD differences are related with changes in solar radiation and not their ratio. I would suggest to put AOD differences instead and change the text accordingly.

Answer:

The suggested change was made. Figure 8a and according text was corrected.

I would suggest to include a table in the end of section 3 including all mean cloudless sky ratios and standard deviations for all factors analyzed (intercomparison, solar angle, ozone, AOD, actual ratios). In order to summarize the quantification of all effects.

Answer:

All cloudless sky ratios and their standard deviations were included in Table 1.

I still think that the latitude difference of the two stations (solar zenith angle effect) as also pointed out from the reviewers can be eliminated. This is because including it to the factors affecting the differences among the sites introduces an uncertainty as it is changes from day to day and in the end in terms of percentage is the most important difference.
This can be done by either normalizing the irradiance of one of the stations using the solar zenith angel functions and compare them again. Or, as suggested, use ratios of measurements (and not 3 or 6 hour averages) for certain solar zenith angle windows e.g. X– 1 degrees where X can be e.g. 45 – 60 – 75 degrees. (75 degrees will capture
the whole year). Then even if the measurements correspond to different time for the two stations, they are only slightly affected by the solar zenith angle issue.

Answer:

We calculated ratios according to Editor's comment. The results are in Table 1 and on P7, L8-12:
"To eliminate the SZA's effect on the ratios, we calculated also mean irradiances ratios for specified SZA windows for cloudless conditions. Calculations were done for SZA windows: 45°±1°, 60°±1° and 75°±1°. For erythemal irradiances, the ratios were 1.02 ± 0.05 (1σ), 1.03 ± 0.04 (1σ) and 1.02 ± 0.05 (1σ), respectively. For UV-A (324 nm) irradiances, the ratios were 1.02 ± 0.05 (1σ), 1.02 ± 0.04 (1σ) and 1.01 ± 0.04 (1σ)."
We also added this result into discussion on P8, L5-8:
"The aerosol effects are responsible for ~2% larger erythemal and UV-A near-noon doses at Belsk, which stays in agreement with calculations of irradiances ratios between the sites for specified SZA windows (45°±1°, 60°±1° and 75°±1°). After eliminating the SZA's effect for cloudless-sky conditions, both erythemal and UV-A (324 nm) irradiances at Belsk were ~2% higher than in Warsaw."

conclusions
As you write (e.g. for the erythemal) you have (roughly) a 6% difference that can be attributed 3-4% on the different solar angles, 1% on the instrument differences and 2% to aerosol difference. So more or less everything is explained. Thus in the paragraph describing albedo and SSA you are mentioning two hypothetical (there are
no measurements) suggestions (a: albedo might be higher in Warsaw site and b. SSA might be lower). I would suggest rewriting this paragraph mostly suggesting that these two parameters (albedo and SSA); a. has been just assumed, b. they can be different and c. there is a possibility that (based on the modeling calculations) the effect of the one is masking the effect of the other. All the above, having in mind that this is a discussion that is not based in actual measurements.

Answer:

The paragraph was re-written to: "(...) We performed RTM simulations to show that the effect of higher surface albedo in Warsaw (the UV irradiances increase) can be compensated by lower values of SSA. We did not measure surface albedo and SSA values. Thus, we assume that the surface albedo in Warsaw can be in the range of 0.03 to 0.12 and 0.03 at Belsk. We also assume, that SSA at Belsk is 0.92, which is a mean value measured by CIMEL photometer at 440 nm. For calculations, we used observed TO_3 and AOD values over Warsaw. SSA=0.86 and 0.85, for SZA=60º and 30º, respectively, were found for the city site, i.e., 0.06 and 0.07 less than the value previously used in our RTM simulations for rural aerosols. Such estimate looks probable, as the Warsaw observing site is located in the most polluted part of the city because of high vehicle emissions from the nearby main city road."

"Our study proves that the UV level inWarsaw is slightly lower than that found in cleaner suburbs of the city. Thus urban aerosols and clouds over Warsaw do not provide an effective shield against excessive UVR"
I would change that to "Our study proves that the UV level in Warsaw is slightly lower than that found in cleaner suburbs of the city. The differences that were attributed due to AOD differences are in the order of the accuracy of the instruments used. Based on the Brewer measurements, urban aerosols and clouds over Warsaw only partially act as an effective shield against excessive UVR.
In addition, it would be interesting to try to justify this conclusion.

Answer:

The last paragraph was rephrased following the Editor's suggestion. In addition, we added a justification of our conclusion on P9, L24-27: "For example, for UV index 5, time needed to get 1 MED (minimum erythema dose) for the person with phototype II is 33 minutes and for phototype III is 40 minutes (Fitzpatrick, 1988). Taking into consideration the attenuation of erythemal irradiances by 4%, which is the summarised effect of aerosols and clouds in Warsaw, this time for both phototypes changes only by 2 minutes. This small difference is not significant for planning and executing routine daily activities."