Author's response by Wenjie Wang et al.

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We greatly appreciate the time and effort that the Referees spent in reviewing our manuscript. The comments are really thoughtful and helpful to improve the quality of our paper. We have addressed each comment below, with the Referee comment in black text, our response in blue text, and relevant manuscript changes noted in red text.

Anonymous Referee #2

1) In the introduction, after the definition of actinic flux (line 68) the authors could include that since the photolysis rates are proportional to the actinic flux and not all stations acquire a 2π spectroradiometer or chemical actinometers for J measurements, several methods have been developed to determine actinic flux and photolysis rates from ground based measurements of irradiance (Kylling et al 2003, Kazadzis et al. 2000, 2004, Topaloglou et al. 2005, Trebs et al. 2009).

Response: Thank you and I have added this sentence in the manuscript.

Line 69-74: Since the photolysis rates are proportional to the actinic flux and not all stations acquire a 2π spectroradiometer or chemical actinometers for J measurements, several methods have been developed to determine actinic flux and photolysis frequencies from ground based measurements of irradiance (Kylling et al 2003, Kazadzis et al. 2000, 2004, Topaloglou et al. 2005, Trebs et al. 2009).

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2) It is stated, in the abstract, that the reduction of J(O1D) and J(NO2) is in the order of 24.2% and 30.4% (for summer and winter respectively) while for the J(NO2) in the order of (27.3 an 32.6%) compared to an aerosol free atmosphere (aod=0?). Since the parametric equations include sza and AOD, the authors could clarifiy how exactly these percentages have been calculated i) to what sza are these percentages referring to? Also for what ozone class for J(O1D)? ii) are these maximum reductions for maximum aod observed or for a mean aod value (i.e. 0.76)? iii) Through which parameters are summer and winter percentages calculated?

Response: Aerosol free atmosphere refers to AOD=0, and I specified it in the

manuscript. We use the parametric equations (Table 5 and Table 6) to calculated J(O1D) and J(NO2) using corresponding SZA and AOD at corresponding time (5 minute average). Two situations are calculated: One, AOD is equal to 0 at all times. Two, AOD is equal to the observed values at all times. For the calculation in the two situations, the corresponding parametric equation at different ozone classes is used according to observed ozone column at different times. The mean values of J(O1D) and J(NO2) for summer and winter are calculated in the two situations and the reduction ratio can be calculated accordingly.

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3) How do the authors comment the (low) r2 coefficient in the linear fits of J(O1D) and J(NO2) versus aod for aod<0.7?

Response: For j(NO2), the relatively large SZ classification width (0.2) is the main cause of the low r2. If we shrink SZ classification width into 0.05, the r2 coefficient will be higher than 0.6. For j(O1D), the relatively large ozone column classification width (30DU) contributes to the low r2 to a large extent. In addition, the nonlinear relationship between j-values and AOD also leads to the low r2 for AOD<0.7.

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4) Concerning the TUV radiation model, information (apart from ssa values) about the input that was used could be included, such as solar spectrum used, aerosol profile etc. In p.2.2 it is stated that global irradiance spectra are calculated. Do you maybe mean actinic flux spectra? Since photolysis rates are proportional to actinic flux, has any comparison been done between the actinic flux measured by the spectroradiometer and that from the TUV model in order to demonstrate the level of agreement?

Response: (1) TUV uses the discrete-ordinates algorithm (DISORT) with 4 streams and calculate the actinic flux spectra with wavelength range of 280-420 nm in 1 nm steps and resolution. I have added it in the manuscript. Aerosol profile is given by Elterman (1968). (2) I have changed global irradiance spectra into actinic flux spectra. (3) I have

simulated actinic flux by TUV to compare with observed results during August 2012, when we have observed SSA data. The agreement between simulation and observation is within 15%. For other time, the simulation couldn't be carried out well due to lack of measured SSA data.

Line 206-210: In order to solve the radiative transfer equation, TUV uses the discrete-ordinates algorithm (DISORT) with 4 streams and calculates actinic flux spectra with wavelength range of 280-420 nm in 1 nm steps and resolution. Measured temperatures were used to calculate the absorption cross sections and quantum yields.

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5) In line 419, the enhanced aerosol level in Bejing is quantified (4-year mean aod = 0.76±0.76). Some references to the studies should be included.

Response: The 4-year mean AOD=0.76±0.75 is calculated by observed AOD during 2012-2015.

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6) In Line 254: "....according to another study in urban Bejing, ..", the reference of the study should be included.

Response: Thank you and I have added the reference.

Line 262-264: According to another study in urban Beijing, the higher the RH, the smaller the slope, and the higher the PBLH, the smaller the slope (Zheng, C. W et al., 2017).

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7) Figure 6: Similar results have been obtained by Bais et al., 2005, Krotkov et al., 2004 and Kazadzis et al., 2017). Is this AOD -SSA dependence from August 2012 obvious during all seasons ? For which wavelength are SSA values given? As both parameters have a wavelength dependence and since PF ozone "effective" wavelengths are ~305-315nm, could this dependence play some role in the provided analysis of the AOD and SSA effects on PFs. ?

Response: Thank you, I have added the sentence "Similar results have been obtained by Bais et al., 2005, Krotkov et al., 2005 and Kazadzis et al., 2017)." In the manuscript. We just observed SSA in August 2012 and thus the AOD-SSA dependence is just available in summertime but unavailable in other seasons. SSA values are at 525nm. The following figure is the relationship between AOD and AERONET based SSA (440nm) during 2012-2015 for all seasons. There is a slight positive correlation between AOD and SSA during 2012-2015 for all seasons. We didn't use AERONET based SSA in this study because that: (1) AERONET based SSA have a large uncertainty; (2) There are only 10-20 data of SSA for most months, which is much fewer than AOD data. Sorry, I don't understanding the meaning of PFs.

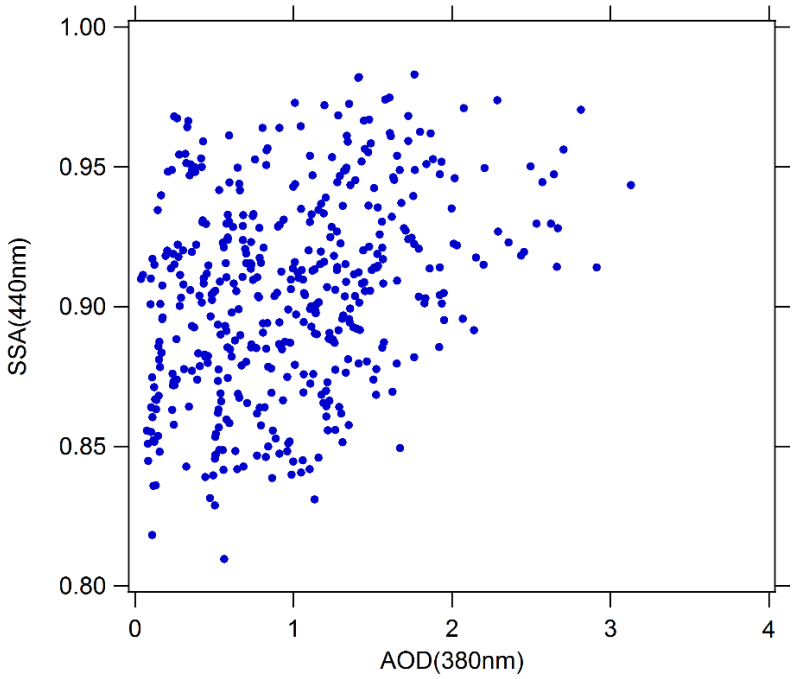

Figure 1. The relationship between AOD and AERONET based SSA.

Line 343-344: Similar results have been obtained by Bais et al., 2005, Krotkov et al., 2005 and Kazadzis et al., 2012.

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8) Figures 4 and 7: Some commentation on the scatter of J's would be helpful Technical corrections.

Response: Thank you and I have added some comments on the scatter of J versus AOD

in page 16 and page 19.

Line 324-325: The scatter of these points is mainly due to variations in ozone column and temperature.

Line 388-389: The scatter of these points is due to the relatively large classification width of SZA to a large extent.

Line 249-250: Repetition of "in summer" "This implies that the aerosols in summer have stronger extinction capacity in summer than in winter"

Response: Thank you and I have revised it.

Line 257-258: This implies that the aerosols in summer have stronger extinction capacity than in winter.

Lines 384 &385: cos(SZA) instead of SZA

Response: Thank you and I have revised it.

Line 398-402: The slope of j(NO_2) vs AOD also displays a significant dependence on cos(SZA). The slope increases as cos(SZA) increases from 0 to 0.5 and then decreases as cos(SZA) increases from 0.5 to 1.

Line 423: "..The result of this study is comparable to the reduction ratio of this study possibly due to..". Probably the one "this study" refers to the previous study mentioned, Hodzie et el. 2007 and the second one to the authors study, it would be helpful to rephrase.

Response: Thank you and I have revised it. "..The result of Hodzic et al. (2007) is comparable to the reduction ratio of this study possibly due to.."

Line 437-438: The result of Hodzic et al. (2007) is comparable with the reduction ratio of this study possibly due to the equivalent levels of AOD and SSA.

Line 559: "...in August 2014..", refers to the field campaign in August 2012, mentioned in the paper.

Response: Thank you and I have revised it.

Line 572-573: In order to evaluate the effects of aerosols on ozone production rate, we carried out an observation campaign in August 2012.