(1) comments from Referees (are marked by italics), (2) author's response (plain text), (3) author's changes in manuscript (are marked by yellow color).

General comments

1. For a more detailed description of the spatial distribution of aerosol over Moscow megacity the authors use the MAIAC aerosol product with a spatial resolution of 1 km. It is reasonable to add a section (or subsection), comparing the obtained results not only with data from ground-based AERONET observations at Moscow_MSU_MO_site and Zvenigorod site (Zvenigorod scientific station of Institute of Atmospheric Physics RAS), but also with data of standard MODIS collection MYDD04_3K (3K AOT product).

Our main task was to try to identify local aerosol pollution by satellite measurements in urban environment. For this purpose we test MAIAIC aerosol product. The previous research was shown that MODIS 3 km product provides higher estimates of AOT on the cite center of Moscow. We added additional information about MODIS 3 km product in the manuscript:

changes in manuscript:

In Discussion it was added:

In previous studies (Remer et al., 2013) MODIS 3 km product based on Dark Target algorithm was shown to have aerosol gradients of better resolution than those obtained from the MODIS 10 km product. However, this product tends to show more noise, especially in urban areas (Munchak et al., 2013). Global validation of MODIS 3 km product exhibits a mean positive bias of 0.06 for Terra and 0.03 for Aqua (Gupta et al., 2018). It was also revealed that that MODIS 3 km product overestimates AOT values for Moscow region (Zhdanova, Chubarova, 2018).

Added references:

Munchak, L. A. L.: MODIS 3 Km Aerosol Product: Applications over Land in an Urban/suburban Region, Atmospheric Measurement Techniques, 1747–1759, doi:10.5194/amt-6-1747-2013, http://dx.doi.org/10.5194/amt-6-1747-2013, 2013.

Remer, L. A., Mattoo, S., Levy, R. C. and Munchak, L. A.: MODIS 3 km aerosol product: algorithm and global perspective, Atmospheric Measurement Techniques, 6(7), 1829–1844, doi:https://doi.org/10.5194/amt-6-1829-2013, 2013.

Gupta, P., Remer, L. A., Levy, R. C. and Mattoo, S.: Validation of MODIS 3 km land aerosol optical depth from NASA's EOS Terra and Aqua missions, Atmospheric Measurement Techniques, 11(5), 3145–3159, doi:https://doi.org/10.5194/amt-11-3145-2018, 2018.

2. It is not quite clear why the authors included in the paper the results concerning the distribution of dAOT for different morning hours (Figures 7-8). Is this still another aspect associated with validation? Why, although presenting data exclusively for morning hours, the authors nonetheless say about diurnal variations of dAOT?

It was interesting to see if there is any change in diurnal (we mean variations in morning and noon hours) change in dAOT using MAIAC data. But we have obtained the absence of significant dAOT changes in morning and noon hours. We decided to remove Fig.7, because it repeats to some extent Fig.8. The changed text is as following:

"For characterizing variations in ΔAOT we analysed frequency distributions according to ground-based and satellite data. In general, polar orbiting satellites demonstrate similar daily average AOT independent of morning or afternoon orbits (Kaufman et al., 2000). However, we calculated ΔAOT separately for Terra and Aqua datasets for evaluating possible diurnal (in the morning and noon hours) variability of ΔAOT. Frequency distributions of ΔAOT at 0.47 and 0.55 μm separately for the Terra and Aqua data, and together for the data from the two satellites are shown in Fig.6. The highest repeatability of ΔAOT is in the range of 0-0.05. For the Aqua AOT retrievals, which are closer to noon, the predominance of positive ΔAOT is more pronounced. Fig. 6 also shows a large negative ΔAOT in cases of Terra measurements in our sample. In overall, the ΔAOT at 0.47 values lie within the [0, 0.05] bin in 57% of cases for the Aqua and in 50% - for the Terra datasets.

The diurnal variations of the ΔAOT according to satellite and ground-based data are also shown in Fig.7. The MAIAC ΔAOT at 0.47 μm are close to zero at the level of median values and do not exceed 0.01.The inter-quantile range of the ΔAOT at 0.47 μm is smaller for satellite data as compared to ground-based data. Satellite and ground-based ΔAOT at 0.47 μm are consistent with each other in the diurnal pattern."

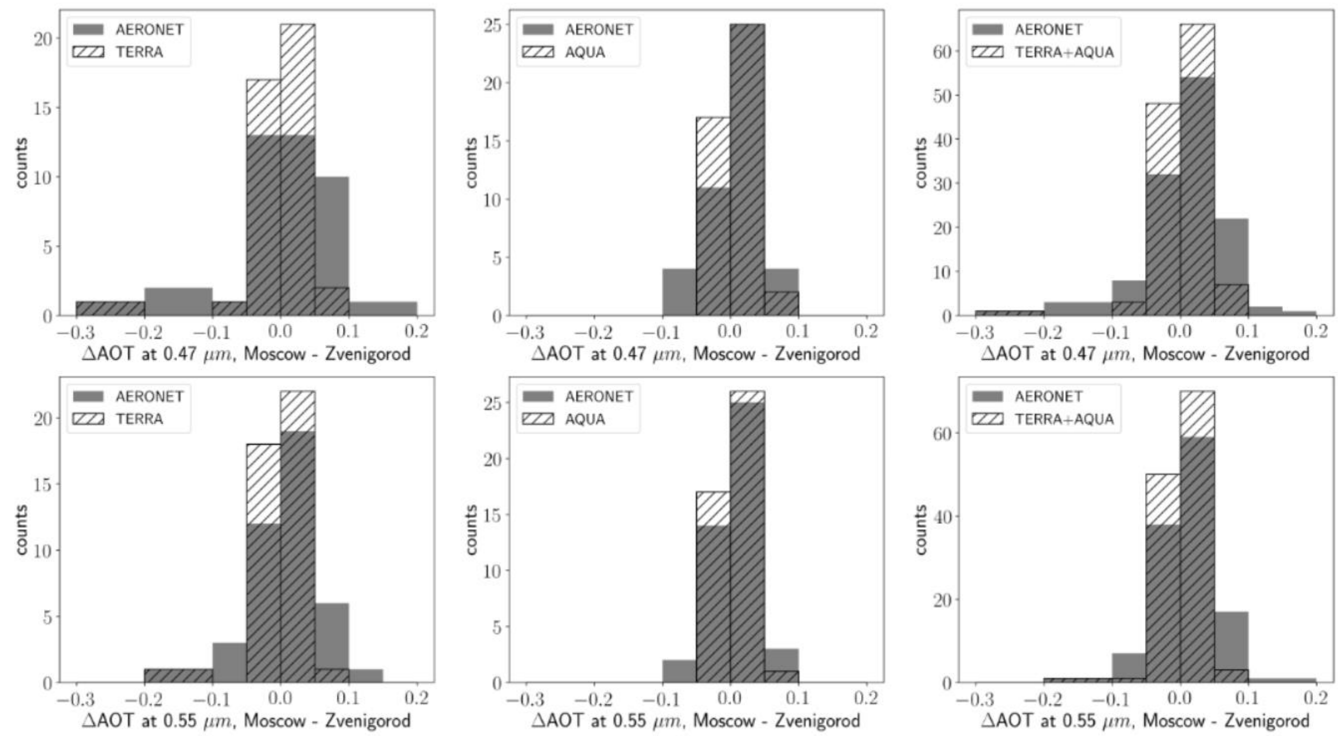

Figure 6. Frequency distribution of ΔAOT ($\Delta AOT = AOT_{Moscow\_MO\_MSU} - AOT_{Zvenigorod}$) at 0.47 µm (upper) and 0.55 µm (low) separately for the Terra (left column) and Aqua (middle column) datasets, and together for the data from the two satellites (right column) with frequency distribution for matching ground-based AERONET data, (2006-2017, without the data of 2009 because of technical problems at Zvenigorod AERONET site). Number of satellite and ground-based matchups is 125.

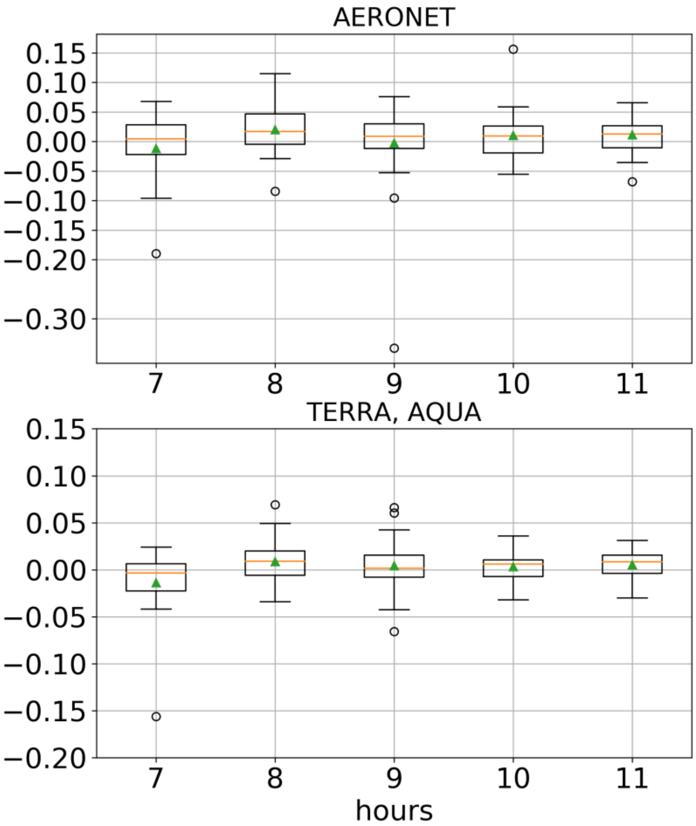

Figure 7. Daily variations of the ΔAOT at 0.47 μm (ΔAOT =$AOT_{Moscow\_MO\_MSU}$ -$AOT_{Zvenigorod}$), UTC time. The median is in the centre, the box is the first (Q1) and the third (Q3) quartiles, the whiskers are Q3 + 1.5 * (Q3-Q1) and Q1 -1.5 * (Q3-Q1), green triangles – means, points – outliers; (2006-2017, without the data of 2009 because of technical problems at Zvenigorod AERONET site). Number of satellite and ground-based matchups is 125.

3. It is useful to turn attention to the paper by Jin et al., Retrieval of 500 m Aerosol Optical Depths from MODIS Measurements over Urban Surfaces under Heavy Aerosol Loading Conditions in Winter, Remote Sens. 2019, 11, 2218; doi:10.3390/rs11192218. That paper appeared after E. Zhdanova and coauthors had already submitted their research for publication in AMT. However, at this stage it makes sense to compare the results, obtained by the authors, with data, presented by Jin et al., 2019

Thank you. We added this paper in the analysis.

In recent paper (Jin et al., 2019) an improved AOD retrieval method for 500 m MODIS data has been proposed, which is based on extended surface reflectance estimation scheme and dynamic aerosol models derived from ground-based sun-photometric observations. Its validation with

AERONET data showed good results – R = 0.89, while our testing of the MAIAC aerosol product over urban territory of Moscow has revealed correlation coefficient R = 0.97.

Jin, S., Ma, Y., Zhang, M., Gong, W., Dubovik, O., Liu, B., Shi, Y. and Yang, C.: Retrieval of 500 m Aerosol Optical Depths from MODIS Measurements over Urban Surfaces under Heavy Aerosol Loading Conditions in Winter, Remote Sensing, 11(19), 2218, doi:10.3390/rs11192218, 2019.

Minor comments

1. Line numbers 124-125: ": : : MAIAC AOT data were spatially averaged with a 5-km circle 125 centred at the Moscow_MSU_MO and Zvenigorod sites: : :". Why circle with diameter (radius?) of 5 km is chosen?

Usually, 27 km radius is chosen for satellite validation of AOT, but we used 5km radius to catch the possible features of the underlying urban and suburban surfaces.

2. Line number 136: ": : : Statistical estimates of the quality of the AOT: : :". Caption of Table 1 indicates precisely what characteristics are considered by the authors. It would be better to move them to the text of the paper because the indicated abbreviations are also used below (see, e.g., line number 364).

We changed the text:

Statistical estimates (RMSE - root mean square error, MAE - mean absolute error, BIAS - mean error) of the quality of the AOT at 0.47 μm retrievals relative to the ground-based AERONET data are presented in Table 1.

3. Figure 2. Information on fitting equation, correlation coefficient, root-mean-square and number of retrieval should be added in the field of the figure.

Fitting equations, correlation coefficients are added on figures, RMSE and Number of retrievals are presented in Table 2.

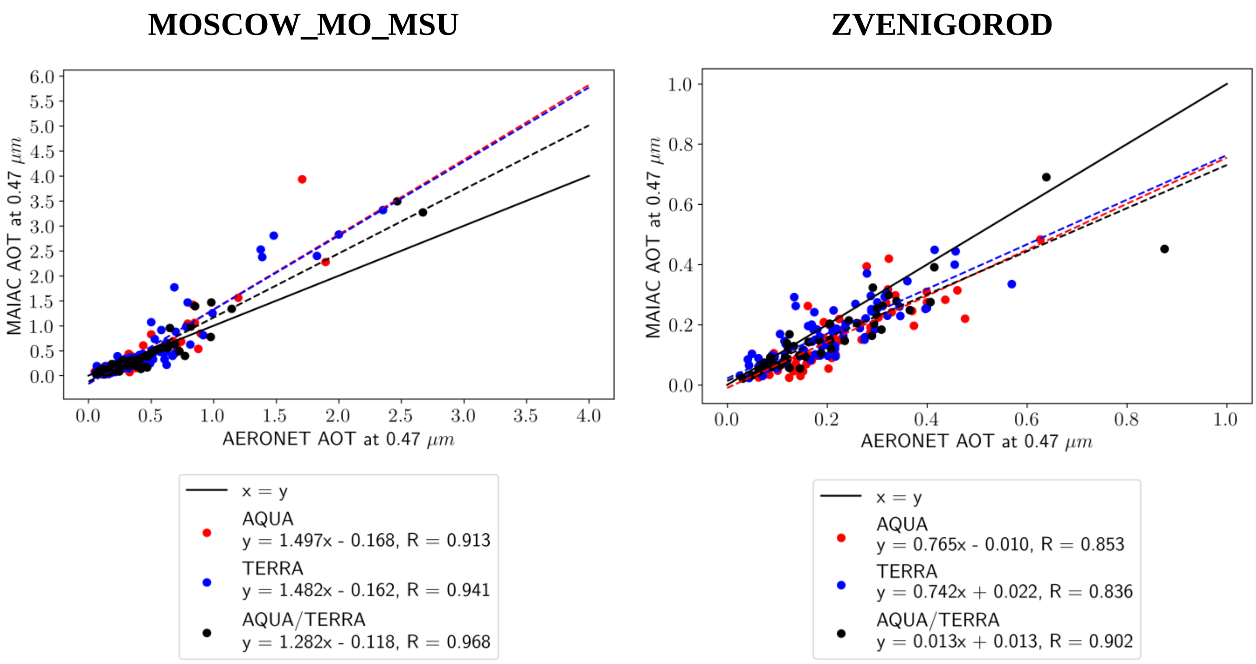

Figure 2. Correlations between MAIAC AOT at 0.47 μm and AERONET AOT at 0.47 μm for Moscow_MSU_MO and Zvenigorod AERONET sites for Terra, Aqua and their joint overpasses within 1 hour (Aqua/Terra).

Comment: the absence of high AOT values at Zvenigorod site is explained by technical problems with the instrument and the absence of the AERONET data at level 2 version 3 in 2010, when intensive forest fires took place.

4. Figure 4 and comments. In section 2 (line numbers 87-88) it is indicated that "MAIAC uses 8 different regional aerosol models tuned to the AERONET: : :". What the data in Fig. 4b, accompanied by the comments "MAIAC", and indication that "MAIAC is regional model", correspond to, in this case?

The geographic distribution of regional background aerosol models over land used in MAIAC processing is shown in Fig. 4 from (Lyapustin, A., Wang, Y., Korkin, S. and Huang, D.: MODIS Collection 6 MAIAC algorithm, Atmospheric Measurement Techniques, 11(10), 5741–5765, doi:https://doi.org/10.5194/amt-11-5741-2018, 2018.), please, see below. Each geographical location has one predefined aerosol model. Aerosol model number 1 is used for Moscow region. Additionally smoke/dust tests are applied.

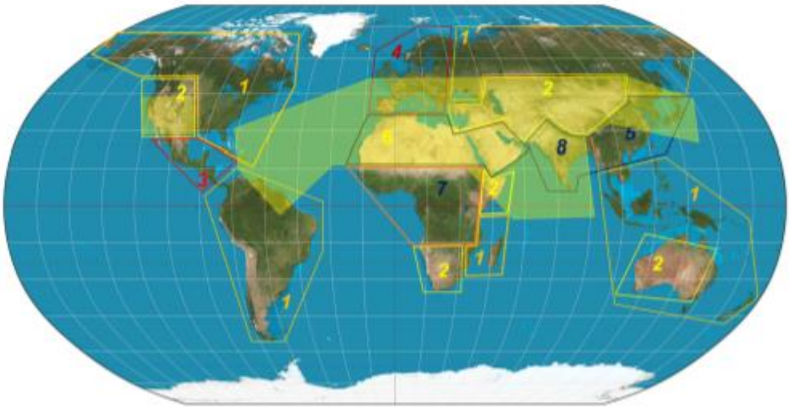

Figure 4. Map of background regional aerosol models specified in Table 1. The transparent yellow shape approximates the dust regions.

Changes in manuscript:

MAIAC uses 8 different regional background aerosol models tuned to the AERONET (Aerosol Robotic Network, (Holben et al., 1998)) climatology. Each geographical location has one predefined aerosol model. Aerosol model number 1 is used for Moscow region.

3.2 Temporal AOT changes in Moscow according to ground-based and satellite data

We studied temporal AOT changes using MAIAC AOT retrievals and AERONET long-term measurements collocated in time over Moscow_MSU_MO site during a warm May-September period. Fig. 4a shows the time series of AOT at 0.55 µm built for all available Moscow_MSU_MO AERONET and MAIAC data. One can see a satisfactory agreement between the satellite and ground-based observations with the exception of 2002 and 2010 years. The highest AOT were observed in 2010 and 2002 years due to the effects of smoke aerosols from peat and forest fires in Moscow region (Chubarova et al, 2011b). In 2016 the smoke aerosol advection was also observed from the Siberia area (Sitnov et al., 2017) providing an intermediate AOT maximum. Fig.4b shows year-to-year variability of AOT at 0.55 µm only for matching within 1 hour Moscow_MSU_MO AERONET and MAIAC data, and for the cases, when MAIAC regional background aerosol model has been applied. One can see a better agreement between MAIAC AOT and corresponding AERONET AOT data in year-to-year variations. There is a clearly seen decrease in AOT during the last years according to both the MAIAC (when regional model was used) and the AERONET data. The yearly means difference between AERONET and MAIAC data (AOT MAIAC – AOT AERONET) is -0.03 for the all matching data (blue and red lines in Fig 4b) and -0.05 for the matching data with MAIAC regional aerosol model estimates (blue and orange lines in Fig 4b). Fig.4c presents the AOT variations only for the cases of the MAIAC smoke detection. It is seen that the AOT MAIAC overestimation is taken place only for the cases with high AOT>1.

Thus, MAIAC AOT reproduces the absolute AOT values and the long-term AOT decrease in Moscow for the regional background aerosol model while in case of smoke aerosol detection there is a significant overestimation of the annual AOT mean. Therefore, for the further analysis of urban aerosol pollution, we used only the AOT MAIAC retrievals with its attribution to the regional background model for removing large smoke aerosol effects, which are also characterized by significant spatial inhomogeneity.

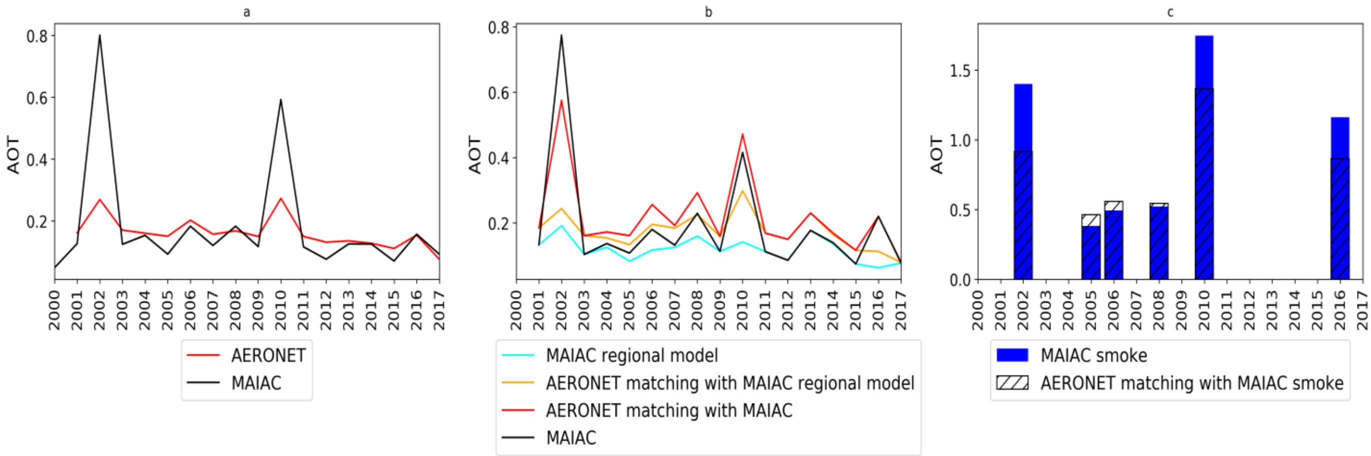

Figure 4. The year-to-year variations of AOT at 0.55 μm (May-September, mean values) according to AERONET (Moscow_MSU_MO) and MAIAC data: a) all available AERONET and MAIAC data, b) matching AERONET and MAIAC data for all cases and for regional aerosol model only, c) AOT MAIAC in cases of smoke detection and matching AERONET data.

5. It makes sense to work on the style of the presentation. For example, within one paragraph the authors write "One can see: : :: : :" (line numbers 327, 330), "We can see: : :: : :" (line number 333), etc.

We corrected the style of the presentation: use only one phrase "One can see", and tried to make the changes in other places of the manuscript.

6. The reference Sever, L., Alpert, P., Lyapustin, A., Wang, Y. and Chudnovsky, A.: An example of aerosol pattern variability over bright surface using high resolution MODIS MAIAC: The eastern and western areas of the Dead Sea and environs, Atmospheric Environment, 165, 359–369, doi:10.1016/j.atmosenv.2017.06.047, 2017 is repeated twice.

Thank you. We deleted the repeated reference.