*The paper discusses the results of aerosol extinction vertical profile and AOD retrievals over Madrid, using MAX-DOAS O2-O2 (O4) measurements in the UV for a period of several months in 2015. The results are validated with sun photometer and PM surface data. A Saharan dust event is analysed in detail.*

The paper is clearly written. The methods used are well-known and described in sufficient detail. The results are interesting, and are relevant to using MAX-DOAS for aerosol detection and profiling.

The main comments are the following:

1. As discussed in the paper, esp. in sect. 4.1, the a priori aerosol profile is very important to get a good profile retrieval, and a good AOD value from the retrieval. It appears that an exponential profile works well for urban aerosols. However, this exponential profile type is not realistic for a desert dust plume, which is an elevated layer of aerosols, including aerosols at altitudes above 4 km. This means that for desert dust events, like the one discussed in Sect. 4.4, another a priori profile should be used in order to get meaningful retrievals from MAX-DOAS retrievals. Please discuss this point, and extend the work of Sect. 4.4 for a Gaussian plume profile of an elevated dust layer.

R: As it can be seen in the Fig.4 (a), the Gaussian profile was distributed as a peaking shape, which was parameterized in the algorithm with: a) the aerosol extinction coefficient of the peak; b) the altitude of the peak. Here, we have selected the Gaussian profile as a priori to retrieve the aerosol extinction during the dusty day. Because the bottom of the Gaussian profile close to the ground surface is extremely low aerosol extinction coefficient, it obviously deviates from the realistic condition. Consequently, the modelled O4 optical depths deviate from the measurements. During dust days, there are considerable aerosol loadings within low altitude, which means that this simplified Gaussian a priori is not suitable for the dust layer retrieval.
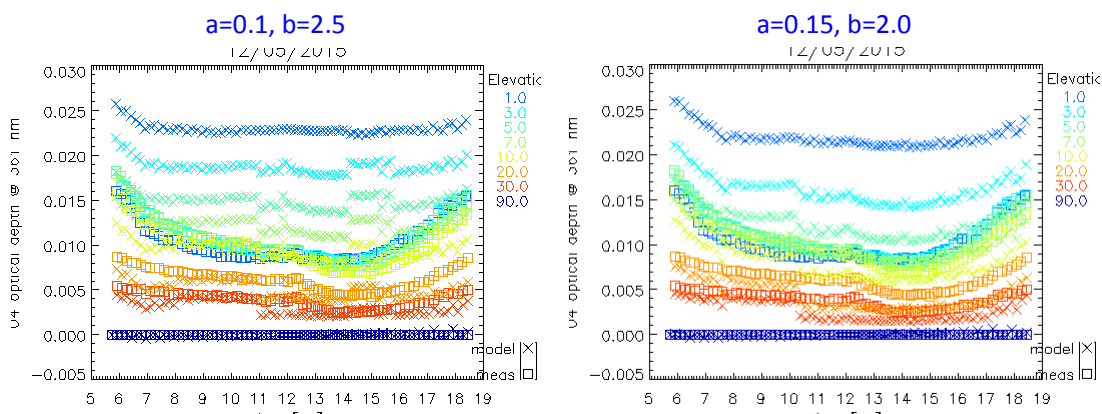
2. It would be better to use an aerosol lidar for validation of MAX-DOAS aerosol extinction profiles. The AOD gives only the total column, and the surface concentration is only one point of the profile. Please discuss. Are there no lidars or ceilometers available in Madrid?

R: Unfortunately, no lidar observation was operated during the MAX-DOAS measurements. We have tried to contact other research groups during the preparation of this paper, however, no

lidar or ceilometers data are available in Madrid. Considering the importance of lidar and ceilometers data to validate MAX-DOAS aerosol profile retrieval, we are planning to gather some other groups to perform a simultaneous measurement combining all the potential instruments in the coming future, e.g. lidar, MAX-DOAS, ceilometers.

3. Use of satellite data, as mentioned on p. 9, l. 22: Daily satellite images of desert dust, visualized with the Absorbing Aerosol Index (AAI) are available from OMI and GOME-2 satellite data. See e.g. the TEMIS website: www.temis.nl, and go to Aerosol Index. These satellite images may help to select desert dust plumes and other elevated plumes of absorbing aerosols.

R：Thanks a lot for the information. We are preparing another paper with the topic of desert dust intrusions in Madrid. These helpful data archives will be used to distinguish the desert dust plumes and other elevated plumes.

Minor comments including textual corrections are:

p. 1, l. 15: by particle > by aerosol particles

R: We have added the 'aerosol' in the sentence.

p. 1, l. 26: of the aerosol's role > of the role of aerosols

R: We have corrected it.

p. 2, l. 20: the NO2 > NO2

R: We have corrected it.

p. 2, l. 24: vertical aerosols > vertical aerosol

R: It has been corrected.

p. 2, l. 28: please specify the period. It is a matter of taste, but a few months is not long for a meteorological time series.

R: We have changed this sentence in the revised manuscript and specified the period.

p. 3, l. 9: responsible to run > running (storing); which offset is meant?

R：These two words have been changed in the revised manuscript.

p. 3, l. 12: the saturation > saturation

R：It has been corrected.

p. 10, l. 16: remove: during day. Please make clear that Fig. 9 contains model AOD fields.

R：'during day' has been deleted. It is now indicated in the caption of Fig. 9 that the shown AOD fields are modelled.

p. 10, l. 24: a cross-section scaling factor

R：'cross-section' has been added.

p. 10, l. 28: exponential a priori profile

R：'profile' has been added.

p. 14, l. 4: Stutz

R：It has been corrected.

p. 15, l. 2: quality

R：It has been corrected.

Figures:

Captions of Fig. 6 and Fig. 7: extinction > aerosol extinction

R: We have modified them.

Fig. 1: please give the lat/lon coordinates as well.

R: Because the different measurement sites are all located within the small area of urban Madrid. It's difficult to indicate the area of the map with lat/lon data. However, the lat/lon coordinates of MAX-DOAS and AERONET can be found in the text of manuscript, and we also have added them in the Fig. 1 itself. The detailed locations of other PM in-situ sites can be referred to *Ayuntamiento de Madrid (AM): Madrid's Air Quality Plan 2011–2015. General Directorate of Sustainability, Government Division of Environment, Safety and Mobility, Madrid City Council, 2012*.

Fig. 2: please order the lines according to increasing scaling factor. Please use a different color for the line with 1.25, since that color is too similar to red (line with 1.0). Please also show the SZA .

R: Figure 2 has been re-plotted with new legend and indicated with SZA as well.

Fig. 3: In b the two red colors are too similar.

R: In order to distinguish different a priori, the color indexes have been updated.

Fig. 4: please add a scatter plot to better see the ratio of MAX-DOAS AOD to Aeronet AOD.

R: It has been shown as Fig. 4(b).

Fig. 5: The figure contains a lot of double information. Please consider omitting figure (a).

R: Both of the Fig. 5(a) and (b) contain the monthly averaged values of AOD from AERONET and MAX-DOAS. However, more statistical parameters that median, $1^{st}/3^{rd}$ quartiles, and $5^{th}/95^{th}$ percentiles are shown in Fig. 5(a), whereas the standard deviations of monthly averaged AODs were indicated in Fig. 5(b). So we prefer to keep both of them in the revised manuscript.

Fig. 6: please indicate in the legend whether hourly or daily data is shown.

R：We have indicated the hourly and daily data with different legends in the Fig. 6(b) and (c), respectively.