We would like to sincerely thank the Reviewers for their support and constructive comments on the manuscript. Their comments have helped to improve the quality of our work. We provide here a detailed point-by-point answer (shown in blue), to their comments and suggestions.

REFEREE 1

Concerning the revisions, I suggest a more detailed discussion in Section 5.3, which can be the core of the results and bring new ideas in this study.

Based on this suggestion and others from Referee 3, we have added some more details to this specific section (from line 499 to line 521).

Technical: (Page 20, line 495) --> The

Corrected (now in line 400).

REFEREE 2

The authors have reacted on most of the detailed suggestions made by myself and another reviewer. They also have added a short section on one scan of HONO retrievals.

Unfortunately, my main point remains unchanged: I do not see what is new in this manuscript with respect to measurement techniques or retrievals, the topics covered in AMT:

* the instrument's ability to measure in several azimuths has been state of the art for MAX-DOAS instruments for many years now

* the DOAS retrieval code used is well documented in previous publications

* the profile retrieval algorithm used is well documented in previous publications

* the onion peeling approach using UV and visible NO2 retrievals was already published and used in several publications

The value of these measurements is in providing information on pollutants in Madrid, and here I do see potential. However, AMT is not the right journal for the presentation of measurement results, and much more data and analysis are needed in order to make this a valuable manuscript for ACP or a similar journal.

We thank the reviewer for the time devoted to read through the paper. We think the paper falls within the scope of AMT: "*The main subject areas comprise the development, intercomparison, and validation of measurement instruments and techniques of data processing and information retrieval for gases, aerosols, and clouds. Papers submitted to AMT must contain atmospheric measurements, laboratory measurements relevant for atmospheric science, and/or theoretical calculations of measurements simulations with detailed error analysis including instrument simulations*".

Our paper contains atmospheric measurements that report the spatial (horizontal and vertical) distribution of NO_2 and HONO, not typically measured by air quality networks, in a European capital, particularly affected by air pollution. Although, the DOAS technique and the corresponding analysis theory is already well published in the literature, we think that its application, comparison with in-situ instruments, and its contextualization about the potential of mesoscale spatially-resolved measurements in air quality research in Madrid further adds to the literature on the potential of MAXDOAS instruments for air pollution research.

On a more technical side, we think that Section 4.2 and the analysis on the sensitivity of the aerosol profile retrieval to different atmospheric profiles can be of interest in the assignment of MAXDOAS derived extinction coefficients to aerosols, particular for layers above the boundary layer.

REFEREE 3

This paper presents nitrogen dioxide and nitrous acid observations over Madrid obtained using a new 2D MAXDOAS instrument. The reported observations show good agreement with mesoscale observations and in-situ measurements provided by Madrid air quality monitoring stations. The capacity of this 2D MAXDOAS instrument to infer horizontal gradients and vertical distribution is discussed as well as future strategies to improve retrievals. The paper is clearly written and the MAXDOAS-2D datasets presented here are a valuable addition to understand air quality in Madrid. For those reasons the paper is worth publication.

However, before publication this paper would benefit of more specific descriptions of technical aspects of RTM calculations and inversion methods. Large extensions of the text are devoted to general descriptions of the theory and methods employed by the authors but if provides insufficient details about the specifics of RTM calculations, inversion algorithms, and protocols used to compare in-situ and MAXDOAS-2D observations. Someone trying to reproduce the results presented here will have a very hard time given the lack of specific details. The minor comments section below specifies some of the sections where further details will be useful.

Thank you for the constructive comments. We have now remove some sections of the text devoted to general descriptions of the theory and methods, and added more details the specifics of the data analysis and results.

Minor comments:

Cloud screening algorithm: How is AERONET information combined with the photos taken by the camera. AERONET observations follow the Sun so how they do contribute to other azimuth angles. It may help to understand better this step and increase confidence in its efficacy to include a plot or a discussion of the cloud screening statistics.

We have added more information regarding the cloud filtering that combines the AERONET observations and the pictures taken by the camera installed in the MAXDOAS-2D. The discussion of the cloud screening statistics is also explained in more detail (from line 269 to 274).

Section 4.2 provides a nice description of the general aspects of profile inversion in MAX-DOAS retrievals but is probably not necessary in a research paper. Particularly if we consider that details about the forward model and the inversion algorithms are limited to one single sentence referencing Clémer et al., 2010. Further technical details would be more helpful to the specialized reader than the general description provided.

We have now removed the general aspects of the profile inversion and we have included more information about the RTM parameters that we have used (from line 286 to line 430).

Since the retrieval is using US Standard atmosphere as unique source of p/T profiles it will be interesting to know how different it is from the typical p/T profiles in Madrid during the observation campaign.

We have discussed about it in lines 389-396. There, we explain that we have carried out several tests concerning the atmospheric profiles. For instance, we took the average surface temperature and pressure values during the campaign (May-July, 2019) and included them into the retrievals. We then constructed the air density vertical profile and evaluated the relative variations with respect to the same air density profile in the U.S. Standard Atmosphere, and found that (within the first 10 km height) the RMS of such relative variations was of about 8 %. It was a small but not negligible change, therefore we decided to push the tests forward, assessing the relative changes produced in their respective light paths. In that regard, we found that the RMS of the relative changes under the same height (i.e. 10 km) were below 2 %, thus we concluded that the main driver of the light path retrievals is the measured O_4 DSCDs and that we could safely chose the U.S. Standard Atmosphere for our studies.

The RTM calculations in the estimation of NO2 horizontal gradients are performed for each VEA or only for VEA = 0. If so, the onion peeling approach is only applied to surface layer mixing ratios?

We have completed this part, from line 502 to line 504, indicating that we are using the measured NO_2 DSCDs at a VEA 1 degree.

Section 5.4 compares in-situ and MAXDOAS-2D NO2 observations looking at the correlation between surface layer retrievals and in-situ observations. While the results here show good correlation they bring little confirmation about the 2D capabilities of the instrument (which is the novel capacity that is presented in the paper) because the comparison is done averaging results over an hour. Would it be possible to analyze qualitative agreement between in-situ and MAXDOAS-2D as function of VAA? How many in-situ stations are finally considered in the comparisons out of the 24 available? Do correlations shown in figure 10 increase or decrease when MAXDOAS VAA is considered in the analysis.

Thank you for this useful comment, we have included in Section 5.4 the remaining stations (line 537). If we divide the azimuthal lap in slices of 20º width for some of them we end up having just one monitoring station, hence we considered that to not be statistically solid, for this reason we done the comparison with the NO_2 surface layer hourly-averaged data.

Technical comments:

Line 24: south-pointing geometry is meaningless without providing an origin. Is this looking towards Madrid's outskirts or towards downtown?

We have marked that is in the southern part of the downtown area (lines 21-22).

Line 61: add dimensions after "both in horizontal and vertical "

Added (line 51).

Line 68: remove comma after monitored

Removed (line 58).

Line 99: remove "will"

Removed (line 83).

Table 1 and table 2: Most likely due to my lack of knowledge but I wonder if Serdyuchenko et al., at 223K was fitted twice or it is a typo.

Thank you, we have an error in the tables 1 and 2. So we have corrected the ozone cross section temperature, one is 273 K and the second one is 223 K.

Figure 3: Would it be possible to include the viewing geometries corresponding to the shown DSCDs fits?

Thank you, the viewing geometries are now included (Figure 3).

Figure 4: It seems that the results presented here are for the whole campaign. Please clarify? How is surface extinction coefficient defined? It would be helpful to illustrate in some way the vertical grid of the retrievals.

We have clarified that this comparison was carried out for a clear sky day (Figure 4.). And, we have included the definition of extinction coefficient (line 364).

Figure 5: I guess is also for the whole period of time.

We have added this clarification (Figure 5).

Line 495: Missing "T" at the end of the line.

Done. Thank you (now in line 400).

Line 536. Vertical profiles are retrieve not only using the RTM explained in section 4. That is one of the components of the inversion algorithm. Besides, details of the RTM are not provided in section 4.

The RTM used in Section 5.1 is bePRO, which has been widely described in previous publications. Nevertheless, we provide a brief description and point to the appropriate references in Section 4.

Figure 6 caption can be expanded to provide further details. What do the red dots represent? It must be some kind of average over the campaign. Besides that, red dots are not simulated or otherwise the x-axes labels "DSCD measured" don't make much sense.

We have included more details regarding the meaning of the graphs (Figure 6).

Figure 10: What represents the radial dimension of the polar plot. The estimated distance from the measurement center? If so, is it the mean distance of each layer with respect to the center?

We have completed the caption of the Figure including the meaning of the symbols (Figure 10).