Response to Anonymous Referee #2

This manuscript combines observations and modeling to interpret the vertical profile and budget of aerosol over Milan. The study is clear and thorough and provides some interesting insights about the vertical profile of nitrate. I have only minor comments below. However the article does need to be edited for language prior to publication (numerous grammatical and phrasing errors).

The authors thank the reviewer for careful reading and valuable comments which improved the clarity of the manuscript. The paper was revised following reviewer's suggestions as detailed below. Moreover, English was edited in the revised version of the manuscript.

1. Abstract, lines 19-23: These results are somewhat overstated given that they are based on one event, and not necessarily generalizable. I suggest clarifying that numbers in particularly are based on the one case study examined here.

All the analysis presented in the manuscript is limited to one short case study in one location is clear from the title. However, we added this statement in front of the bottom line of the abstract: "Although the results presented here are relative to one relatively short period at one location, …"

2. Page 26411, lines 9-11: what size ranges do the 2 submicron modes cover?

We overlooked this information. The dry diameter of the two modes is in the range 50-200 nm, but they have different hygroscopic properties, one hydrophobic and the other hydrophilic, as already mentioned in the manuscript.

3. Page 26413: lines 5 and 17: please comment on why differing OM:OC ratios (1.6 and 1.8) are applied.

1.6 and 1.8 are applied as factors to convert OC to OM and WSOC to WSOM, respectively. These conversion factors are reported in the cited literature as reasonable values for urban environment.

4. Page 26413, lines 7-9: how far away are the weather and monitoring stations from the aerosol measurement site?

The gas and weather station run by the local environmental agency is in the same suburban area (Via Juvara) of the Torre Sarca aerosol site. The distance of the two sites is about 5 km, thus well within the 10 km of the model horizontal resolution.

5. Page 26415, lines 20-21: what types of SOA are included in the simulation?

SOA in the VBS mechanism implemented in WRF/Chem originates from the oxidation of anthropogenic and biogenic VOC currently believed relevant for SOA production. These include alkanes, alkenes, xylenes, aromatics, isoprene, mono- and sesqui-terpenes. Full details are provided in the cited reference Ahmadov et al. (2012). We added a sentence in the text " …, which include the oxidation of anthropogenic and biogenic VOC currently believed to be important for SOA production (alkanes, alkenes, xylenes, aromatics, isoprene, monoterpenes, and sesquiterpenes)."

6. Page 26415, line 19: the name of the thermodynamic model is MAR-A not RPMARES

We thank the reviewer for the clarification, the actual name was not clear from the references and from comments embedded into the code.

7. Page 26417, lines 3-5: Has this model been validated using TNO emissions? If so please include references.

The model was validated with TNO emissions in the frame of AQMEII intercomparison. We added the two relevant references (Im et al., 2014a,b).

8. Page 26420, lines 25-29 & page 26422, lines 17-22: Please comment on how the lack of dust in the model may impact the comparison to observations.

Regarding the Saharan dust event after 17 July, we excluded the days from the analysis because of the lack of representation of that contribution. We added this sentence at the end of paragraph on page 26420: "Since Saharan dust intrusions are not modelled here,

these days are excluded from the analysis.". Regarding the bias on PM10 commented on page 26422, we added the following sentence: "The negative bias of PM10 could be partly explained by the missing source from soil dust erosion and resuspension in the model."

9. Page 26423, lines 8-9: Please comment/explain the poor model performance for nitrate shown in Figure 5.

We added the following comment: "Recently reported hourly measurements of PM composition in the Po Valley indeed confirm the same "pulsed" behaviour of nitrate near the ground, with values near zero during daytime, and irregular peaks nighttime (Decesari et al., 2014). This highlights the inherent difficulties in simulating the nitrate concentrations at sub-daily frequency."

Decesari, S., Allan, J., Plass-Duelmer, C., Williams, B. J., Paglione, M., Facchini, M. C., O'Dowd, C., Harrison, R. M., Gietl, J. K., Coe, H., Giulianelli, L., Gobbi, G. P., Lanconelli, C., Carbone, C., Worsnop, D., Lambe, A. T., Ahern, A. T., Moretti, F., Tagliavini, E., Elste, T., Gilge, S., Zhang, Y., and Dall'Osto, M.: Measurements of the aerosol chemical composition and mixing state in the Po Valley using multiple spectroscopic techniques, Atmos. Chem. Phys., 14, 12109-12132, doi:10.5194/acp-14-12109-2014, 2014.

10. Page 26423, line16: what kind of SOA? Biogenic? Anthropogenic? From where?

Both biogenic and anthropogenic with about the same share, from the larger region around Milan. We haven't added more comments in the manuscript, since this is distracting from the main discussion.

11. Page 26423, lines 20-29: comment on how the model compares to the lidar profiles

The paragraph was revised as follows. First of all we corrected a wrong reference to Hodzic et al. (2006) to Hodzic et al. (2004) at the beginning of the same paragraph. We now revised the last part of the paragraph for a more clear and sharp guidance to the features we would like to bring to reader's eyes. We now focus on days 14-16 July, in place of 16-17 July, because they better illustrate those features. Here is the revised part of the paragraph:

"Then, in the afternoon, the mountain-valley breeze cleans the lower PBL (note the abrupt abatement of both the Lidar and the model aerosol signals in the second part of the day), often leaving an upper air aerosol residual layer above. Model simulations also reproduce such residual layers (note the afternoon increase of PM2.5 values in the upper levels, particularly visible on July 15-16). When such residual layers persists overnight, the Lidar shows these to entrain into the developing PBL the day after (note the merging of the upper level aerosol layers with the growing, aerosol-traced PBL in Figure 6a, particularly evident in the morning of July 14 and 15). There are hints of the same features also in model simulations."

12. Figure 7: color scale makes it difficult to see features. I suggest different color bars be used for different panels, as appropriate

We agree that the scales somewhat hide the simulated features, however the same color scale makes the intercomparison of PM species contribution very direct. Moreover, the relevant features discussed in the text still emerge (e.g. homogeneity of sulfate and SOA profile in the PBL, correlation of ammonium with nitrate). We prefer to leave the Figure 7 as is.

13. Page 26424, line 11: what do you mean by primary? Only those emitted particles? Is this BC and POA in your simulation? Please clarify.

This is also primary inorganic and unspeciated anthropogenic fraction. We changed the (inorganic and organic) in parentheses to (unspeciated anthropogenic, black carbon, and primary organic carbon).

14. Figures 9, 10, 11: orange and pink are difficult to distinguish. I suggest changing one of these colors.

Done. Pink changed to black.

15. Page 26425, line14: why was this time chosen? Is it representative of the entire period? Could the authors instead show an average over a longer period of time?

The time chosen in representative of the typical budget during the central part of the day, and highlights the more interesting features emerging in the vertical profile budget discussed in the rest of the manuscript. We believe that averaging on several hours will not change the picture emerging from this snapshot view.

16. Page 26426, line 23: please add temperature profile to Figure 12

Done.