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comment

Interactive comment on "Evaluation of the LOTOS-EUROS NO$_2$ simulations using ground-based measurements and S5P/TROPOMI observations over Greece" *by* Ioanna Skoulidou et al.

Anonymous Referee #2

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The paper "Evaluation of the LOTOS-EUROS NO2 simulations using ground-based measurements and S5P/TROPOMI observations over Greece" by Skoulidou et al., presents LOTUS-EUROS NO2 simulation over Greece, for a period of 7 months, from June to December 2018. The data are compared to in-situ NO2 concentrations for the whole period at 14 sites in Athens and Thessaloniki, then to 2 months (June and December) of tropospheric NO2 VCD from MAX-DOAS instruments in Athens and Thessaloniki and from TROPOMI. Differences as a function of the season are discussed. The scientific content of the paper fits the scope of ACP, and the paper is interesting,

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although a bit difficult to read due to length and repetition in several sections. The number of tables and figures could also be reduced. It is a pity that profiles are not exploited a bit more. It would be nice to have: 1) comparisons of the LOTOS-EUROS NO2 profiles wrt to TROPOMI a-priori profiles from TM5, and 2) at the MAX-DOAS stations, profiles retrievals (instead of only tropospheric VCD from geometrical approximation) could be used as a link between the surface NO2 from the in-situ and the tropospheric VCD from TROPOMI. Moreover, the LOTUS-EUROS profiles could be used to test a relation between surface and tropospheric VCD, and test this assumption with the in-situ and MAX-DOAS measurements. I would thus recommend some revision of the text and some further investigations, as described below.

specific comments:

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- why not compare also to MAX-DOAS from June "to" December (as for the in-situ) instead of June "and" December?

- Are MAX-DOAS profiles available? they could make the link between surface NO2 values from in-situ and tropospheric VCD

- Also how are the LOTOS-EUROS NO2 profiles comparing to TROPOMI a-priori profiles from TM5?

- how are the TROPOMI AVK applied to the LOTUS-EUROS model? It is said that gridded data are created from TROPOMI pixels. Are the AVK averaged to created a grid of AVK?

P4, L 114: there are 10 levels "from the surface to a top around 175 hPa (about 12 km)." Are all the levels of same width?

P4, L 150: "For this reason, stations characterized as urban traffic stations, localised close to busy traffic roads of the city and showing very large values, are excluded from the validation." –> how this selection is done? we still have urban traffic sites in Sect

3.1...

P5, L.160: why only "for July and December" and not between July and December as for the in-situ comparisons (or over the whole year)?

P5, L.165: why the 15° elevation has been chosen and not the 30° elevation? is there any further selection, as in Drosoglou et al., 2017 where an average of both elevations was considered if the results from the 2 angles are within 20 or 30% ?

P5, L.166: both the azimuth 220° and 255° are looking over the sea. Do you have viewing directions in the same direction than the in-situ measurements (from AUTH to Lagada and Kordelio (this last name and Sindos are difficult to read in Figure 2))?

P5, L.181: for Athens, the geometrical approximation is also used, but from which elevation angle? also 15°, as for Thessaloniki?

P5: please specify if MAX-DOAS data are filtered for clouds, and give an estimation of the errors on the tropospheric VCD for both sites. Are they of equivalent quality? Please also discuss the MAX-DOAS horizontal representativeness area (or at least mention the outcome from Drosoglou et al., 2017 and Gratsea et al., 2016). Are these taken into account in the comparison, or is the MAX-DOAS considered as a "point measurement" in the horizontal plane?

P6, Fig2: in this figure, several in-situ stations are in the line of sight of one of the MAX-DOAS azimuth direction. Do they show similar diurnal variation? or can these be compared using the model profile shape to convert surface to tropospheric VCD? Similarly, adding the extension of the LOTOS-EUROS 0.1°×0.05° grid on these maps, could help the reader understanding if several in-situ stations are in one model grid cell.

P6, L..203: "that because the averaging kernels are used in our case, the comparison with LOTOS-EUROS is not influenced by the retrieval a-priori (Eskes and Boersma, 2003" –> this is the case for LOTOS-EUROS vs TROPOMI, but not eg for the LOTOS-

EUROS vs MAX-DOAS comparisons. Moreover, this is a bit misleading, as the coarse apriori model profiles would still play a role. Are the TROPOMI AVK also gridded "onto the LOTOS-EUROS grid at $0.1° \times 0.05°$." (P.6, L 208)? How are the AVK applyed? Please explain.

P7, Sect 3.1: what is the width of the first model level, that is compared to the in-situ surface concentrations? The discussion would be more easy to follow if instead of the tables 1 and 2 (or in addition, maybe in the supplement) a few plots of the diurnal variation of the in-situ and the model at the sites is shown (a bit like figures 7 and 10). It would be more easy to also understand why the 12-15pm is selected as representative of "daytime" conditions and 0-3am of "night" condition. Are there big changes outside these periods? It would also allow to draw a conclusion on the consistency (or not) of the diurnal surface NO2 variation compared to the diurnal NO2 VCD variation.

Figure 7 and 10: what would be the MA X-DOAS if retrieved from $30°$ elevation instead of $15°$?

P20, Sect4: the main messages are a bit lost in the conclusion, which is a bit too much a repetition of each subsection conclusions.

Technical comments and corrections:
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P2, L.71: (Zerefos et al., 2000.) –> (Zerefos et al., 2000).

P4, L.117: what is the "tree-species database"?

P4, L.135: 2.2Ground-based –> add a space after the section number

P4, L.143: give some references for the chemiluminescence method

P5, L.172: quantify "good agreement"

P6, L.194: "several TROPOMI NO2 validation papers that have been recently submit-

ted (Judd et al., 2020; Verhoelst et al., 2020)." –> there are some TROPOMI NO2 validation papers already fully published: Zhao et al 2019 (https://www.atmos-meas-tech-discuss.780net/amt-2019-416/), Ialongo et al., 2020 (https://doi.org/10.5194/amt-13-205-2020)

P7, L.229: "the correlations are very good (r=0.69 and 0.63" –> remove "very"

P7, L.234: "In this case, a clear seasonal pattern in the model's performance, as is the case for Thessaloniki, was not found." –> do you have any hint why?

P7, Table 1 and 2: please add the units of the RMSE.

P10, L.283: please add in Figure S3 caption or ylabel, the definition of relative biases. (simulation-obs)/obs? Also, it could be nice to have a different symbol for each site, so that it would be clear for the reader which site(s) are the outliers of the whiskers in Winter and night conditions. Either 14 symbols, either grouped by station types introduced in tables 1 and 2, either one color per Athens, one per Thessaloniki...

P10, L.394: please specify how "spatial correlation coefficient" and "temporal correlation" are calculated.

P10, L.298: "representation issues related to the location of the stations" –> link with the Drosoglou et al., 2017 study with high resolution model (6km resolution for the Balkans and 2km resolution for the Thessaloniki region)

P11, L/ 320: "The MAX-DOAS in the center of Thessaloniki observes high NO2 columns during the winter months and lower levels during the spring season..." –> is this a description of the rest of the MAX-DOAS dataset, not shown here, or is "spring season" mis-referring to July data or to the Drosoglou 2017 results?

If other months than December and July are available from the MAX-DOAS, how are they comparing to LOTUS-EUROS?

P11, L.237: "The daily mean" - how are the daily mean performed? is it , as for the

in-situ, only 12 to 15pm, or is it all the available points (below 75°SZA)? Is there a difference between the 2 approaches for MAX-DOAS data?

P12, L.355: are the MAX-DOAS data cloud filtered? if there are some gaps in the MAX-DOAS, are these gaps considered also in the model data, before doing the daily average?

Figure 7 and 10: please increase a bit the size of these figures. The legend is diffcult to read.

P15, L.423: "the MAX-DOAS tropospheric columns in both cities have been derived using the geometric approximation without taking into account the actual NO2 profile, introducing therefore, additional uncertainty" –> please estimate this error.

P15, L424: "the one azimuthal directional observation in Athens compared with a grid cell of the model may not be representative of the relatively large grid pixel of the model simulation, underestimating a possible horizontal plume from industrial areas i.e. from chimneys" –> mention and discuss a bit more the MAX-DOAS horizontal representativity and the model size.

P15, L.434: "The averaging kernels are applied directly by the LOTOS-EUROS model" –> "by" or "to" ? Explain better how the AVK are applied (gridded AVK? application of AVKK at the pixel level, and then gridding? ...?)

P15, L.447: Pandora measurements in Helsinki are total columns!

P15, L 452: "there is no NO retrieval profile-related bias influencing the comparisons" –> NO to NO2 this is partially true, but the influence of the coarser TM5 1x1 degree resolution instead of a regional high resolution model is still present (see Zhao et al., 2019).

P15, L.455: "the profiles of LOTOS-EUROS peak more strongly near the surface" –> it would be interesting to see the comparison of the profiles shapes (TM5 vs LOTOS-EUROS).

P17, L.488: "In December (Figure 12, middle panels) LOTOS-EUROS simulates high NO2 columns (mean value $\sim 5 \times 10^{15}$ molec.cm2) near the Isthmus of Corinth, which are not supported by the TROPOMI observations, pointing to a possible overestimation of the NOx emissions in the area" - it could maybe also be related to winds that do not add up? It would be nice to see the TROPOMI December map if the winds speed and direction would be taken into account to create the map (Zhao et al., 2019; Lorente et al., 2019)

Lorente et al., 2019: https://www.nature.com/articles/s41598-019-56428-5

Zhao et al 2019: https://www.atmos-meas-tech-discuss.780net/amt-2019-416/

Ialongo et al., 2020: https://doi.org/10.5194/amt-13-205-2020

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-987, 2020.