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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 #3

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The authors compare the LOTOS-EUROS simulations of NO2 over Greece against surface measurements, DOAS profiles and sentinel maps during the second half of 2018. The comparison is also performed at different seasons, sites and hour of the day, and the authors provided reasoning for the differences. The paper is within the scope of the journal and it is scientifically sound. My main concern is on the significance of some results, which affects its emphasis and extent. I trust it should be published, following the recommendations hereafter.

Specific Comments 1. The validation approach relies mainly on correlation and RMSE.

The linear correlations should be tested for their significance. The same applies also for the spatial correlations, for which, the estimation algorithm is missing. Use of NRMSE is more informative when comparing the simulations at different stations.

The sum of the linear correlations are tested as commented by the reviewer for their significance calculating the p-value and the results found are commented throughout the manuscript. In the case of the comparisons of the simulations with in-situ data we found that the p-value is in all cases much lower than the significance level (a=0.05) and the correlation is statistically significant as added in the updated manuscript. In the case of the MAX-DOAS comparison with LOTOS-EUROS simulations in the region of Thessaloniki in July and December the correlation coefficients are statistically significant for a=0.05. In Athens it was found that only over the rural direction in July the correlation coefficient is not statistically significant. When comparing TROPOMI and LOTOS-EUROS, the spatial correlations are found statistically significant for all the regions and periods while the temporal correlations over Thessaloniki in July and Greece in December found statistically not significant.

Moreover the estimation algorithm of the spatial and temporal correlation is added in the text as recommended by the reviewer:

“Note that in this work temporal correlation refers to the correlation between the average daily values of TROPOMI and the simulations in each region while spatial correlation refers to the correlation between the monthly average observations and the corresponding simulations in each grid cell of the region.”

Further the NRMSE instead or RMSE is used at tables 1 and 2 following reviewer’s recommendation.

2. Can the authors comment on the impact of the 24h periodicity to the temporal correlations?

Diurnal variation plots of representative stations of the in-situ stations are added in the supplement (S3, S9 S10)

3. The way and reason some stations have been excluded should be re-framed to be less qualitative.

The official designation of the station type was assumed to be that one reported in the official databases, however due to our detailed knowledge of where those stations are located we decided to exclude ones that are exactly over busy thoroughfares in Athens. It follows that those stations are directly affected by the smallest changes in road emissions and their reported measurements far noisier than stations that are within the city canopy but not directly on a busy road. We have included the following sentence in the text:

"For this reason, stations characterized as urban traffic stations, localised close to busy traffic roads of the city and showing extremely high concentrations were excluded from the validation, based on local knowledge of their actual locations. As a result, we include in our analysis stations that are officially characterized as "traffic stations" (e.g. Marousi station, Athens) but which are not placed directly over the major thoroughfares."

4. The comparison of the gridded LOTOS-EUROS simulations against point measurements needs some clarifications. Ideally, one should either compare the observations with the simulations pin-pointed at the station location or the model grid values with the cluster of observations falling inside.

Two pairs of air quality stations in Thessaloniki are indeed located in the same grid as can be now seen in the updated Figure 2, which includes the actual grid we are working with. We now include in our analysis the average observational levels of the two urban background stations (Malakopi and AUTH) that are situated in grid-pixel [22.95E, 40.625N] and the average of the urban industrial stations Sindos and Kordelio in grid–pixel [22.85E,40.975N] in Thessaloniki. However Figure 1 becomes very busy when the actual grid of the model run

is plotted, and since the main purpose of Figure 1 is to depict the orography of the two areas and to give the reader a general idea of the regions of study and their surroundings, we opted to keep the original gridlines.

5. Uncertainty estimates require a more rigorous framework, with a better description

Following the reviewer's comments on the uncertainty estimates we used error bars in Figures 7 and 10 referring to the standard deviation of the averaged MAX-DOAS observations and LOTOS-EUROS simulations. Furthermore, new figures added, according to another reviewer's comments, showing the diurnal variability of the in-situ measurements and simulations with their standard deviation of the averaged values as a shaded area (Figures S3, S9 and S10). Moreover, the tropospheric NO_2 precision of the TROPOMI data provided by the TROPOMI product has now been added at Figure 13 in the shaded area to provide a more quantitative description of the TROPOMI observations.

6. The comparison of the gridded LOTOS-EUROS simulations against satellite data needs some clarifications on the TROPOMI data regridding and the application of the averaging kernel in LOTOSEUROS.

The process of the implementation of averaging kernels onto LOTOS-EUROS model is made directly by a module of the model. It is true that it is not clear in the text how the averaging kernel are applied so a better description is added in the manuscript, as follows:

"The TROPOMI averaging kernels are applied onto the LOTOS-EUROS profiles using an online module of LOTOS-EUROS. After regridding the TROPOMI data onto LOTOS-EUROS gridding, the module maps the model profile to the retrieval a-priori layers, while in order to cover the atmosphere above the model's vertical levels boundary conditions are added from the CAMS NRT product. The averaging kernels are applied to the simulations made at the closest time of the observations. The entire process is fully automated within the LOTOS-EUROS post-processing analysis tools."

Technical Comments

Tables: Please specify which correlations are significant.

Following the reviewer's comments we have added which correlations are significant throughout the text.

Figures: The information in some figures is not easily seen (e.g. Figure 4, 5).

Some figures are changed in order to be more easy to read them. As an example, Figure 4 is made larger (Figure 3 in the new changed manuscript), in Figure 5 (Figure 6 in new manuscript).

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