

***Interactive comment on* “Sudden changes in nitrogen dioxide emissions over Greece due to lockdown after the outbreak of COVID-19” by Maria-Elissavet Koukouli et al.**

Anonymous Referee #2

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Koukouli et al. present the changes in NO₂ pollution levels in six major Greek cities resulting from the COVID-19 public health measures. They use satellite observations from the TROPOMI instrument and model simulations using the LOTOS-EUROS CTM. They find an average decrease in TROPOMI NO₂ abundancies of -22% in March 2020 and -11% in April with respect to the 2019 levels over these cities, which is mostly attributed to traffic restrictions. The model simulations for 2019 and 2020 using the same anthropogenic emission inventory can inform about the contribution of emission changes to the observed column. This study adds to an growing body of literature on the effects of COVID-19 on air pollution. It is timely and the first study discussing the effects of COVID-19 measures on air quality in Greek cities. However, the discussion

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is generally somewhat limited, and in many instances, the analysis of the results is unconvincing. The article suffers from many typos and language errors and will need a careful rereading before resubmission. I recommend publication after my concerns listed below are adequately addressed in a revised version.

Major comments

1) The decreases along the shipping lanes are interesting but not sufficiently discussed. How does the model perform along the major lanes and how does it compare to the observed decrease? What do shipping activity data tell us about the changes in traffic during the shutdowns? Can you provide a map of the column differences between March 2019 and March 2020 over the sea? From Figure S2, it is clear that a large hot spot located to the east of Athens in March 2019 disappears in March 2020. Is this due to a reduction of ship activity or to meteorological changes? A detailed model-data comparison along ship tracks should be presented. Figure S2 should also be moved to the main manuscript.

2) The comparisons with in situ stations are important for validating your results and should be part of the main text. These comparisons could help to interpret the changes sensed by TROPOMI. Although these comparisons should be taken with caution, it is very important to compare the satellite-based changes with the changes measured locally.

3) I have serious doubts about the derived strong emission decrease (-37%) in Patra (Figure 5). Possible reasons for such a change should be analysed and discussed. Is this change expected based on in situ observations? Another concern is the 26% increase in emissions in Athens during the last week of April (Figure 7). Is this increase due to increased anthropogenic emissions (traffic, energy or industrial sectors) or can this be attributed to modelling uncertainties and/or noise in the data?

4) At the end of Section 2.3, the authors claim that that TROPOMI NO₂ averaging kernels are not needed because only relative column changes are considered. This

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argument is not entirely correct. The averaging kernels could very well be different in 2019 and 2020, and their effects should not be overlooked. I strongly recommend their use in the revised manuscript, or, some demonstration that their effects can be ignored.

5) Sampling problems are not adequately discussed. Some of the model-data discrepancies could be due to sampling issues. For how many days are data available per month and per city? Is this taken into account in the comparisons with the model?

6) The column decreases in March are more important than in April, as turns out from Table 2. This is at odds with the full lock-down period that you mention in Section 1.4 (23 March to 4 May). One would expect the decrease to be more significant in April than in March. How can we explain this? Do we have evidence that the lockdown was not (or less) enforced in April? As a matter of fact, the in situ data (Figure S1) indicate that the decreases are stronger in April than in March. A discussion is warranted. Moreover, there is inconsistency between the values for Heraklion of Table 2 and Figure 4.

Minor comments

There is a recurrent problem with the format of citations. The authors should follow the journal guidelines for literature citations. Footnotes should be removed. Consider adding them in the reference list or insert them in the text (e.g. for URLs). The article needs to be corrected for typos and language mistakes. Consider a careful reading before resubmission.

- I.24: "second largest sector", which is the first one?
- I.31: "we aim to show the quantifiable and beyond doubt decline", rephrase e.g. as: "we aim to quantify the decline"
- I.33: read "hereafter"
- I.36: "we enumerate the improvement", do you mean "we quantify the improvement"?
- I.51: remove "among others"

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- I.53: remove "issues"
- Section 1.2: Too many details that are not used afterwards. Consider rewriting to ease readability. In I.73, do you mean "by 2.1%" lower? in I.77, remove 'the work of". In I.80, "If we assume that years 2019 and 2020 were not exceptional": what do you mean by exceptional? In I.82: "will not bare a significant of the emission", something is missing here. Reread carefully.
- I.92: read 'reductions'
- I.95: '25% decrease'
- I.98: update reference
- I.103: Add more references for other regions of the world where lockdown effects on air quality have been studied.
- Section 1.4 is very long and too much detailed. This information is not used later on in the discussion. To interpret the results, one needs to know the beginning and end of the lockdown per city. Was the lockdown nationwide? You could replace this section by a table including this information for easy reference.
- I.111: "coffee shops"
- I.121: remove "discreet".
- I.121-122: The sentence can be removed. In fact, hardly any dates have been used afterwards.
- I.133: read "point"
- Figure 2 is mentioned before Figure 1 in the text. What is the benefit of showing Figure 1?
- Figures 1 and 2 are not easy to read. Can you improve the scale? We cannot even see higher columns in Patra or Heraklion. In Figure 2, could you add additional panels

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with the column differences?

- I.169: "distinct", do you mean "specific"?
- I.173: explain what MAX-DOAS stands for
- I.182: This is repeated elsewhere, reread carefully to avoid repetitions.
- I.197: read "wind speed"
- Table 1, Figure 3 and I.249-259 have a lot of repetitions.
- Why do you show the month of March in Figure 3? From Section 1.4 it looks like March was for only half affected by the measures. Wouldn't it be more interesting to show April
- I.312-317: the discussion should be extended, see point 1 above.

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