Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC2
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# Comment on amt-2022-135

Anonymous Referee #1

Referee comment on "A new machine-learning-based analysis for improving satellite-retrieved atmospheric composition data: OMI $SO_2$ as an example" by Can Li et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-135-RC2, 2022

**Review of manuscript "A New Machine Learning based Analysis for Improving Satellite Retrieved Atmospheric Composition Data: OMI SO2 as an Example" by Can Li et al. 2022**

In the manuscript a new and interesting method to minimize noise and artifacts using machine learning has been presented and applied to OMI SO2 data. The paper is well written and only minor revisions are needed.

My **main comment** is that an optimization (or sensitivity analysis) of the applied NN architecture is missing. A simple NN architecture from a completely different scientific field ("for reconstruction of RGB images from hyperspectral radiances") was used. In general a simple architecure is fine as a starting point, but what I am clearly missing is a sensitivity analysis of much the NN architecture is affecting the results.
Furthermore I suggest some restructuring of the paper - I think it would be good to start with the simple approach of using the linear interpolation model and then begin the NN model.
Althoug the comparison and different maps are nice to see, I suggest to also add line plots as a function e.g. latitude such that is easier to see biases and differences.

**Detailed comments:**

- Sect.1, L49: Please provide numbers or references for the background noise of OMI SO2 SCDs.
- Sect 1. L80ff: The 20 DU limit of the FP-ILM retrieval only applies to the SO2 LH retrievals. It was not yet applied to SO2 VCD retrievals
- Sect 2.1, L109: How are pixels with enhanced SO2 after volcanic eruptions detected/filtered? Do you apply a VCD threshold? Please describe
- Sect 2.1, L128: By how much do the monthly medians/stddev change every month? Do you see jumps in the results from one month to the other?
- Sect. 2.2, L146: I am a bit concerned that the a1/a2 factors are based on trial and

error and there is no robust criterion to determine them. This makes appying the whole method to other sensors (or even to OMI for a different time span) difficult - I assume the factors will vary over time, especially related to instrument degradation. Can you perhaps show how sensitive your results are to (small) changes in a1/a2?

- Sect 2.3, L180ff: As already mentioned in my main comment, I am a bit concerned about the choice of the NN architecture. Although it is a good starting point to use a simple archictecture, it definitely needs to be optimized for the specific problem, especially independently for your NN1 and NN2.
  Is there a reason for the choice of activation functions? I.e. using soft-sign and then sigmoid is not really common - I suggest to use ReLu or something related for both hidden layers.
- Sect. 4.3: I suggest to put this in front before you apply the NNs, to show that a simple linear interpolation is not sufficient and therefore you apply NNs.
- Figure 4&5: Suggest to add line plot of SCD as a function of latitude. With this plot you probably better see biases and the differences
- Figure 5: Suggest to use different color scale from -0.1 - 0.1
- Figure6b: Relative differences are always problematic for SO2 plot since in clean areas the SCD is close to zero and hence the relative difference becomes extremly high, as can be seen in the figure. Suggest to use absolute differences here.
- Figure 7: The maps are rather confusing and do not provide addtional information. I sgueest to rather repleace them by line plots as a function of e.g. latitude (see my comment above)
- Figure 9&10: Suggest to add line plots of SCD as a function of e.g. latitude. With this plot you probably better see biases and the differences