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Atmospheric Measurement Techniques Discussions

Interactive comment on "Benefit of ozone observations from Sentinel-5P and future Sentinel-4 missions on tropospheric composition" *by* Samuel Quesada-Ruiz et al.

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"Benefit of ozone observations from Sentinel-5P and future Sentinel-4 missions on tropospheric composition" by Samuel Quesada-Ruiz et al.

Anonymous Referee #1 Received and published: 8 March 2019

We thank the anonymous reviewer for his/her valuable remarks and we answer point to point to the comments.

General comment:

In this paper, Samuel Quesada-Ruiz et al. evaluated the benefits of assimilating ozone observations from sentinel-5P and sentinel-4 in the MOCAGE- PALM system using a synthetic study in the European domain. They quantified the improvements and deterioration of O3 profile results at levels of 200, 500, and 700hPa by adding the new satellite observations. Since the real ozone profiles can not be well known for the real measurements, the synthetic study with CTM simulations of real atmosphere is a state-of-art way for the research purpose. In general, the scientific topic is meaningful, research method is novel, and presentation is quite concise.

I have one general concern. In the simulations of S4 and S5P ozone observations, the transformed AK, which is derived from the DISAMAR inversion package, is used to convert the true ozone profile from the nature run to the measured ozone profile. The AK is not only as a function of atmospheric statement and measured geometries, but also depends on settings of optimal estimations, e.g. covariance of a-priori and measurement uncertainties. And the measured ozone profiles calculated with the AK can further impact the final ozone profile results from the assimilation run. The benefit of S4 and S5P ozone observations is concluded based on the assimilation run. Therefore the conclusion might be specifically for the DISAMAR inversion package. The benefit might be different if other inversion algorithms are applied to the ozone retrievals of S4 and S5P observations. Considering this, the authors should clarify that the conclusion is based on the DISAMAR inversion package and might be different for other algorithms of ozone retrievals in the abstract and conclusion part.

Specific comments:

1) The abbreviations of nature run, assimilation run, and reference run might not be needed. It is easier for readers to understand the paper if the original words are written in the manuscript.

We will avoid all the acronyms that concern nature run, assimilation run and reference run throughout the manuscript, except for the figures.

2) P3, L3-4: The data assimilated to the MOCAGE-PALM system should not be the ozone data simulated from the nature run. As I understand, the data should be simulated ozone observations with the ozone data simulated from the nature run. Please check the sentence.

Right, we change the sentence as required by the reviewer.

3) P4, L29: The free run is not explained in the paper. Please check.

The free run has been removed from P4 L29. It is not required in the paper as the comparisons of the assimilation runs are based on the reference run.

4) P5, L32: "The simulated ozone observations from GBS" should be based on the nature run results and assimilated into the MOCAGE-PALM. Please check the sentence.

Yes, this is correct, the sentence is now changed.

5) Section 4.2.1: Since the spectral analysis of ozone is not applied in the synthetic study, how do you consider the uncertainty of spectral analysis for satellite observations?

The answer to the general concern and question 5 contains several elements: the radiative transfer code, the a-priori, the chosen uncertainty on the radiance and irradiance, absolute calibration of the instrument, and the representativity error. We will comment on each of these elements separately: - The DISAMAR radiative transfer / retrieval code was used. DISAMAR, which builds on the Doubling-Adding code of KNMI (DAK) has been compared extensively against other state-of-the-art radiative transfer codes, and generally the quality of the retrieval is not limited by which code is used, but much more so by the input parameters such as instrument noise. - The a-priori. Indeed, the retrieved profile will depend on the a-priori and a-priori covariance. However, as explained by Migliorini (2012), in contrast the assimilation results are not (or only weakly in the case of non-linearity) dependent on the a-priori in the retrieval because the averaging kernel effectively removes this a-priori dependence. So, also

the a-priori is not a limiting factor. - The assumptions for the SNR of the radiance and irradiance are described in the beginning of section 4.2. This is strongly wavelength dependent towards the UV because of the strong decrease of the signal. We believe that this choice of radiance noise is realistic for TROPOMI and we assume that the SNR for Sentinel-4 will be comparable. - The absolute calibration of the instrument is a much more serious issue and may lead to a systematic distortion of the profile shape. Unfortunately, such absolute calibration issues and instrument degradation can not be known before the instrument is in space. We assume that these errors are zero, or that this is a systematic feature which has been corrected for by soft calibration. In the case of TROPOMI (launced in October 2017) this turned out to be a major issue (after launch) and soft calibration is needed there. For other instruments, such as e.g. GOME-2, soft calibrations to correct for systematic biases and degradation have been applied with quite some success. - The representativity error: we believe that a nice aspect of our paper is the estimation of the representativity term, as described in section 4.2.1, table 1. In theory, the variance of the different eigenvector observations is 1.0, but in practice interpolation and coincidence errors increase the total observation error, and it is well understood that especially vector 1, which has a very small relative retrieval error, is mostly affected. So, we think we have an efficient representation of this term.

To conclude: we do not think the choice of the DISAMAR package or a-priori has a major impact on the results. Also, the SNR assumptions are realistic. In practice, the unknown calibration and degradation errors will be the most serious additional uncertainty on top of the uncertainties reported in our study.

S. Migliorini, On the Equivalence between Radiance and Retrieval Assimilation, Mon. Wea. Rev 140, 2012, DOI: 10.1175/MWR-D-10-05047.1

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