## Reply to Anonymous Referee #1

We thank anonymous referee #1 for her/his positive review and the helpful comments and corrections. Please find below the reviewer's comments (in black), our responses (in blue), and changes or additions to the text (in red).

## Anonymous Referee #1, 06 Mar 2025

The manuscript by Coldewey-Egbers et al. presents a very interesting and innovative merged ozone profile data set from nadir observations (GOP-ECV). The authors introduce the main aim of the work, the harmonization procedure used for the merging of the data sets and the scaling procedure with respect to the GTO-ECV time series. This paper fits the scope of AMT, it is well written and scientifically sound. I found the given explanations overall convincing, with clear descriptions of the multiple, and sometimes complicated, steps. From my side, I only have some minor comments on specific aspects and some technical corrections.

## Specific comments/questions

I am wondering about the usage of SCIAMACHY data set over the period 2002-2004, as reported in Tab.1. Is it only used over these two years for the generation of GOP-ECV? Does the usage until 2012 have a negative impact on the merged dataset? I would suggest to include a short explanation in the manuscript about this choice. Regarding limb observations, in Sofieva et al. (2017) the usage of the first months of SCIAMACHY were not recommended due to some unexplained features in the anomalies (for SAGE-CCI-OMPS it is used from August 2003). Have you noticed any larger discrepancy in nadir data at the beginning of the SCIAMACHY period?

 $\rightarrow$  SCIAMACHY data is used for the generation of GOP-ECV as follows: We use 6 years (2005-2010) of the overlap period with OMI for the estimation of the bias and drift correction, that is then applied to the entire SCIAMACHY time period (incl. 2002-2004). Since we do not have overlap with OMI from 2002-2004, we cannot compare our results with the findings in Sofieva et al., 2017.

In the final merged data record, we use SCIAMACHY data only for the period 2002-2004 in order to bridge the gap between GOME (this sensor unfortunately lost its global coverage in June 2003) and the beginning of the OMI measurements. OMI then provides a very good spatial coverage. We included a short explanation in Section 3.

OMI time series is used in this work as reference for the other datasets, also to remove drifts. Does the drift affecting OMI total column time series or its row-anomaly, e.g. Torres et al. (2018), Gaudel et al. (2024) supplements, have any potential impact on this choice?

 $\rightarrow$  We agree that the quality of the merged product will be determined to a large extent by the quality and long-term stability of the OMI data record. OMI is used not only a a reference sensor for the profile product, but also as a reference sensor for the total column product GTO-ECV. It is possible that the changing cross-track coverage during the mission could influence the OMI time series if sampling of L2 data is not restricted to the cross-track pixels which were continuously usable.

In the framework of the EU Copernicus Climate Change Service (C3S) ozone project, OMI total ozone and ozone profile data are validated using ground-based data on a regular basis. For both data records, it was found that the drift with respect to the ground reference is mostly insignificant (see C3S PQAR).

C3S Product Quality Assessment Report: https://dast.copernicus-climate.eu/documents/satelliteozone/C3S2\_312b\_Lot2\_2024/C3S2\_312a\_Lot2\_D-WP2\_FDDP-PQAR\_202311\_O3\_v3.3\_final.pdf Just a couple of clarifications regarding the used neural network approach, as I am not very familiar with this.

Is the described NN approach a sort of ozone profile retrieval?

 $\rightarrow$  In our study, the sole purpose of the NN approach is the estimation of the Jacobians, which provide the information about the altitude-dependent change of the profile due to a change in the total ozone column. During the training process, the ozone profile serves as the output, but the mapping from the input (total ozone, month, lat, lon) to the profile (output) is not used for the construction of the GOP-ECV data record.

However, in a study by Xu et al. (2017), a similar NN approach is used as part of an ozone profile shape retrieval, i.e. for the scaling of the profile shape according to the total column (see their Fig. 1(b) and Sec. II-E).

J. Xu, O. Schüssler, D. G. L. Rodriguez, F. Romahn and A. Doicu, "A Novel Ozone Profile Shape Retrieval Using Full-Physics Inverse Learning Machine (FP-ILM)," in *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, Vol. 10, No. 12, pp. 5442-5457, doi: 10.1109/JSTARS.2017.2740168, 2017.

Are the derivatives extracted in a second step or directly provided by the NN?

→ The derivatives are directly provided by this NN implementation developed by Molina García:

Molina García, V.: Retrieval of cloud properties from EPIC/DSCOVR, Ph.D. thesis, Technical University of Munich, https://elib.dlr.de/194303/1/MolinaGarcia\_Dissertation.pdf, 2022.

Molina García, V., Efremenko, D. S., and del Aguila, A.: Automatic differentiation for Jacobian computations in radiative transfer problems, Oral talk presented at 21st European Workshop on Automatic Differentiation, Friedrich Schiller University Jena, Jena, Germany, 2018.

In the simplest case from Tab.2, are you feeding the NN only with TOC for each class and let the hidden layers find a mapping between TOC and profile shape? It seems to me that in this case there could be profiles with the same TOC but different shape even within the same class. I just wonder how the NN is able to distribute the TOC variations vertically without having unique solutions.

 $\rightarrow$  It seems that the NN is able to deal with it, but the quality of the model using only TOC as input is worse compared to the models using additional input information.

How do you get to the number 420 in Table 2? I understand the 242 possible combinations in Table 3, as you have 2 hidden layers and 11 possibilities for each, times 2 options for the inputs, but I could not get to 420 combinations in Tab.1.

→ The number 420 in Table 1 results from 4 options for the number of hidden neurons (10,20,30,50) and the variation of the number of hidden layers (1,2,3). In case of 1 hidden layer this leads to  $4^1$  possibilities, in case of 2 hidden layers, we have  $4^2$  possibilities (e.g., [10,10],[10,20],...), and in case of 3 hidden layers, there are  $4^3$  possibilities (e.g., [10,10,10], but I tested also for example [30,50,30]). In total, there are 84 (=4+16+64) combinations times 5 options for the input (1st row in Table 1).

A side note: is the spiky shape of the profiles in Fig. 5 a feature of the RAL retrievals? Most of them tend to have three local maxima.

 $\rightarrow$  The jagged appearance in the figures is simply due to changing layer thicknesses.

## **Technical corrections**

Line 13: I would add "presented in this manuscript" after "the homogenization".

 $\rightarrow$  Added as suggested.

Line24: "banned" → "prevented"

 $\rightarrow$  Changed.

Line 30-31: "the middle latitudes of the Northern Hemisphere"  $\rightarrow$  "at northern mid-latitudes"

 $\rightarrow$  Changed.

Line 59: Add a , after "data sets".

 $\rightarrow$  Comma added.

Lines ~60: You could mention the advantage/disadvantage to use limb or nadir data to retrieve profiles in terms of vertical and spatial resolution.

 $\rightarrow$  We added the following sentence after line 65:

"In contrast to limb satellite sensors, the nadir sensors benefit from a higher horizontal resolution and sensitivity also to the troposphere. On the other hand, their vertical resolution is limited."

Line 79: "allows us to generate"  $\rightarrow$  "enables the generation of"

 $\rightarrow$  Changed.

Line 80: "in particular important"  $\rightarrow$  "particularly important"

 $\rightarrow$  Changed.

Line 82: What is it meant with "investigation of changes in the profile"? Stratospheric ozone trends?

 $\rightarrow$  Yes. We have reworded this sentence:

"In addition to investigations of vertically-resolved trends,..."

Line 85: "enables us to assess"  $\rightarrow$  "facilitates the assessment of"

 $\rightarrow$  Changed.

Line 97: Add , after "ozone profiles".

 $\rightarrow$  Comma added.

Line 98: The UVN acronym was already introduced in the previous page.

 $\rightarrow$  Removed.

Line 160: Add , after "level-2 products".

 $\rightarrow$  Comma added.

Line 202: Also at northern mid-latitudes SCIAMACHY has a positive bias.

 $\rightarrow$  We have added the NH mid-latitudes in this statement.

Lines 205-207: I would move this last three lines to the beginning of the paragraph (line 194), as these are general considerations about the seasonal cycle.

 $\rightarrow$  Agreed.

Line 216: "drift" is repeated two times.

 $\rightarrow$  Corrected.

Lines 220-222: Do you plot in Fig. 2 the fit, for example, to (GOME-OMI) anomalies (as you state in the text) or to OMI-GOME?

 $\rightarrow$  We show the fit, e.g., OMI-GOME. The statement in the text and the figure caption was wrong and has been corrected.

Line 227-229: I find hard to read the sentence starting with "From these deviations...". I suggest to reformulate such as: "From the time series of the offsets in each available spatial bin, at first, we calculate averages for each calendar month ("climatologies") and then we average them over five broad latitude bands...".

 $\rightarrow$  We reformulated the sentence as suggested.

Line 242: "aligning" or "harmonizing"?

 $\rightarrow$  Changed to "harmonizing".

Line 262: "in particular as to the..."  $\rightarrow$  "in particular in terms of the..."

 $\rightarrow$  Changed.

Line 328: Remove , after "requires".

 $\rightarrow\,$  Comma removed.

Line 360: "of the parameters total ozone..."  $\rightarrow$  I would add "of the parameters, i.e. total ozone..."  $\rightarrow$  Agreed.

Line 371: Add , after "in advance"

 $\rightarrow$  Comma added.

Line 402: "only for example poleward of 50° N for 120°-180°"  $\rightarrow$  "mostly at latitudes poleward of 50° N and at 120°-180° E."

 $\rightarrow$  Changed.

Line 436: "measurements from"  $\rightarrow$  "measurements over"; "data from"  $\rightarrow$  "data over".

 $\rightarrow$  Changed.

I would remove Line 446 as it repeats what said in the previous lines.

 $\rightarrow$  Changed.