Response to Referee

We thank the reviewer for the suggestions. Below we give the reviewer's comment, our response, and the changed text in the manuscript.

General remarks:

1. I was happy to see the extra figure 11 added, showing Polyphemus vs. Tropomi. However to my opinion figures R1, R2, R3 and R4 are also relevant to the reader. I would suggest that R2, R3 and R4 are added in the supplement, and that the the resolution effect (R1) is summarised in 1-2 sentences in the main text, section 4.2.

We have included R2, R3, and R4 in the supplement, and included the texts in Sect. 4.2 as "*Sections S1 and S2 in the supplement compare the POLYPHEMUS/DLR NO_2 results with data from ground-based stations as well as the regional chemistry transfer model LOTOS-EUROS, indicating that POLYPHEMUS/DLR is in general reliable.*" We have included the discussion of resolution (R1) as "*An additional increase of the spatial resolution from 0.2x0.3 to 0.1x0.1 degree affects the tropospheric NO_2 columns moderately by up to 5×10^{14} molec/cm^2 or 11% for polluted regions.*" in Sect. 4.2.

2. (Fig. 9) There is clearly a big difference in the VMR of TM5-MP and Polyphemus between 800 and 400 hPa. To my opinion TM5-MP may be more realistic here. Regional model often neglect processes like lightning, aircraft emissions or deep convection which are of importance for the free/higher troposphere. This impacts the overall profile shape. Please comment on this and the possible implication for the retrieval.

To avoid confusion we would like to address that Fig. 9b shows the normalized profiles (instead of the original profiles), as indicated in the texts, which show large differences between 800 and 400 hPa. We agree with the reviewer that the global TM5-MP model considers additional processes such as lightning, with enhanced NOx injected into the upper troposphere (Williams et al., 2017). We have calculated the tropospheric AMF with POLYPHEMUS/DLR NO_2 concentrations at 400-800hPa increasing from ~0.02 to ~0.05 (approximately TM5 values) ppb, and the impact on NO_2 retrieval is limited (smaller than 1%) for the example in Fig 9.

3. The emissions in the model are outdated. Using reported negative trends in NO2 (e.g. EEA air quality reports), how much of the difference in Fig. 11 could be explained by this?

Figure R1 shows the tropospheric NO_2 columns from POLYPHEMUS/DLR simulations with the TNO-MACC emissions from the year 2011 and 2018. The update of emissions reduces the overestimations of tropospheric NO_2 columns by up to 50%, which likely

explains ~50% of the difference in Fig. 11. We have included the texts in Sect. 4.2 as "An update of the POLYPHEMUS/DLR model using the more recent TNO-MACC_II emission is planned for the near future, *which reduces the overestimations of tropospheric NO_2 columns by up to 50%*."

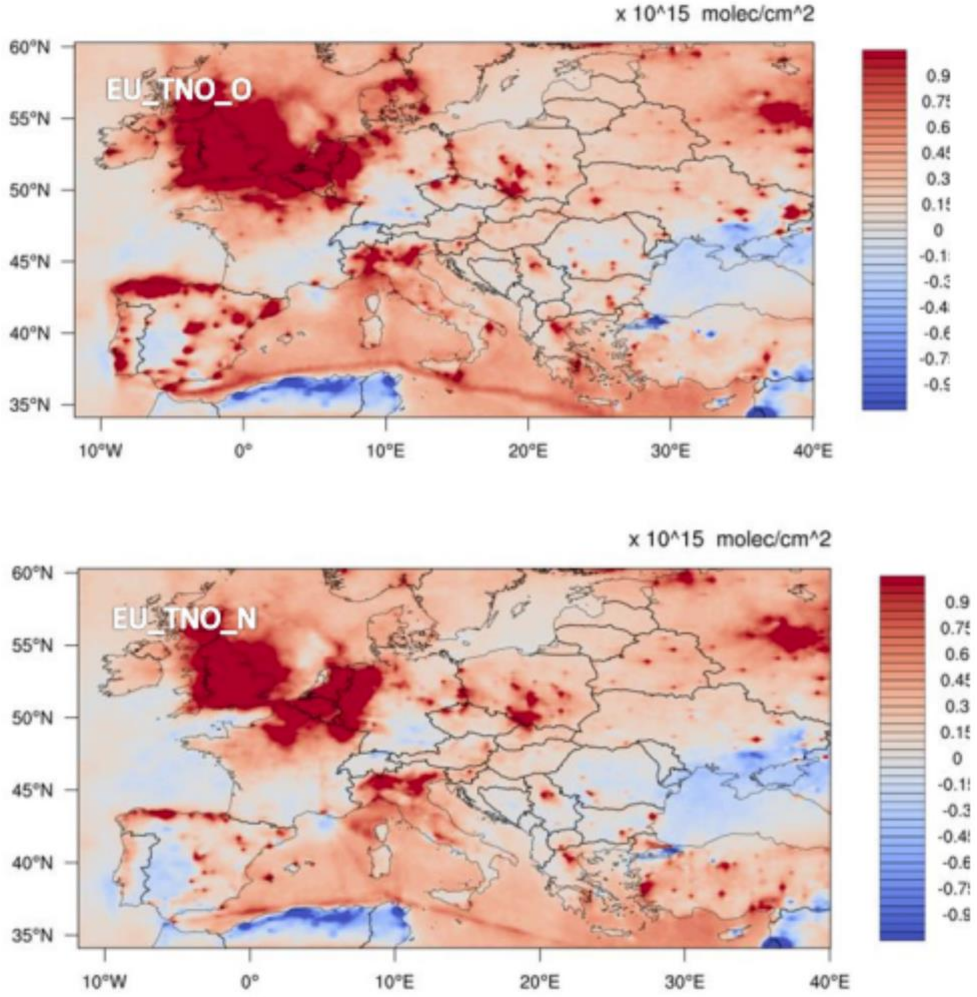

Figure R1. Tropospheric NO_2 columns from POLYPHEMUS/DLR simulations with the TNO-MACC emissions from the year 2011 (top) and 2018 (bottom) with the TNO-MACC emissions from the year 2011 (top) and 2018 (bottom) over Europe in July 2018.

4. Concerning my question about "I am wondering if there is any interference between DSTREAM and the destriping?" It was good to see the answer from the authors and Figs R7/R8. However, I would like to see a few sentences in the paper, section 3, to summarise this. Also my question "Can the difference with the model (3.5e14) be considered a true uncertainty estimate?" Also here it would be good to see a modification in the paper text, section 3.2.

We have included the texts in Sect. 3 as "The de-striping correction is implemented before STREAM, but only small-scale variation is removed.". We have included the texts in Sect. 5.2 as "(*the values can be regarded as a lower limit due to the use of the finite resolution for the synthetic data*)".

References

Williams, J. E., Boersma, K. F., Le Sager, P., and Verstraeten, W. W.: The high-resolution version of TM5-MP for optimized satellite retrievals: description and validation, Geosci. Model Dev., 10, 721–750, https://doi.org/10.5194/gmd-10-721-2017, 2017.