Atmospheric Measurement Techniques Discussions

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Comment on amt-2021-308

Anonymous Referee #1

Referee comment on "Horizontal distribution of tropospheric NO_2 and aerosols derived by dual-scan multi-wavelength multi-axis differential optical absorption spectroscopy (MAX-DOAS) measurements in Uccle, Belgium" by Ermioni Dimitropoulou et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-308-RC1, 2021

The manuscript „Horizontal distribution of tropospheric NO2 and aerosols derived by dual-scan multi-wavelength MAX-DOAS measurements in Uccle, Belgium" by E. Dimitropoulou is a highly relevant paper for the community. It is well-structured and thought through.

I am no expert on optimal estimation, therefore my contribution to the chapter 4.3 is limited.

I strongly recommend the publication, after considering the following comments:

General comments:

- In my opinion a distinction between the VCD_NO2 and c_NO2 measured in main viewing direction (retrieved by traditional profile inversion) and the values retrieved in other azimuthal directions would help a lot for clarification (e.g. page 9 line210, page 10 equation 1, page 11 equation (4))
- Inventing a new name for this new technique would help especially when comparing to other data-sets (e.g. in chapter 5.2). Usually, elevation scans are called "MAX-DOAS". Something like "Mapping MAX-DOAS" would help to distinguish between the different kind of retrievals.
- Is a seasonal analysis really useful for NO2? An analysis sorted for different temperature regimes could be more useful. Also, an analysis sorted for several wind regimes could be interesting, especially as 3 huge NO2 emitters are in the region.
- The RIO data is available in an hourly model. It would be interesting to see a comparison to this data set.
- In a future study the comparison could also be performed for AOD with the 1km resolution data from MODIS.
- Harmonize axes and color bars of plots in one figure.

Specific comments:

- Page 2 line 29: If possible, restructure sentences for a better reading flow.
- Page 6 figure 2: Why are the reference lines not exactly at the maximum of O4 for all windows?
- Page 7: line 55: DDS is defined, what is the difference between DDS and DDS2?
- Page 7 table 1: Data products 01.03.00 and 01.03.01 have an overlap in time. What is used in this period?
- Page 8 figure 3: In yellow box last line: "1 EA, many TAA"
- Page 8 line 205: Is all data flagged for clouds or only the main viewing direction?
- Page 9 line 211: Add an equation, as this value is used in all future calculations.
- Page 10 line 235: Replace ":" by ",".
- Page 10 line 252: State clearer, that this sentence refers to the old paper.
- Page 11 line 276: Equation (4) and the following sentence are confusing next to each other (I understood it after reading the next two pages). In the equation is written dSCD_NO2_simulated, in the text are mentioned simulated O4 DSCDs. Explain in more detail.
- Page 11 line 281: Was the impact of this fixed NO2 concentration investigated? If typical high values for Brussels are used, does the retrieval significantly change?
- Page 12 line 298: "are" instead of "is" (or restructure sentence)
- Page 13 line 307: Which order is the polynomial fit?
- Page 13 line 310: Is this statement also true for the high pollution cases in Brussels?
- Page 13 line 314: (see Fig. 6 (a))
- Page 16 equation (6) and (7): For readability it would be good to include the missing step between the two equations
- Page 17 equation (7): possible space character in subscript
- Page 22 equation (11), middle line: Confusing definition. If written like this, it should be x(first) >L_NO2 (the first value which extends over L_NO2).
- Page 23 line 536: If this is true, why do the lines differ in figure 13 and 14 for the first km from the a priori? And why is the information of this region used in the later comparisons if this information cannot be trusted?
- Page 25 figure 11: Add wavelengths and change colors (see https://www.color-blindness.com/coblis-color-blindness-simulator/). Add also time of the measurement.
- Page 26 figure 12: Same y-axis for all
- Page 27 figure 12: Mention RIO in caption
- Page 27 figure 13: Adjust both axes to the same values, add (a) and (b)
- Page 28 figure 14: Add a priori of aerosol distribution. Are errors available?
- Page 32 figure 16: For consistency it would be good to see the values corresponding to figure 13
- Page 33 figure 17: It is claimed before, that the measurement is insensitive for the first kilometers. It would be good to mark this range (e.g. draw a line). Why is the y-axis limited to 11km?
- Page 33 line 664: Is the wind direction and speed stable over the measurement period? What is the wind speed?
- Page 34 figure 18: The wind direction could be added to the plots. If possible, the latitude and longitude range could be shortened to make the plot bigger.
- Page 35 line 695: Mention typical overpass time of TROPOMI. Is every measurement from TROPOMI used? Even when several are available for one day? And is the exact time of the overpass used or the typical overpass time? The NO2 distribution can change quickly. Were also other time ranges used for comparison? (+/-30Min)?
- Page 35 line 698: How does this simplification (no weighting) influence the results?

- Page 35 line 706: Can this be explained/expected? (Different sensitivity…)
- Page 36 line 723: Are the retrieved values high/low, compared to typical values for this region?
- Page 37 figure 19: Add MAX-DOAS maps in original resolution for comparison with original APEX. Also, the RIO analysis could be added. Use the same color scale for all plots!
- Page 38 line 759: Point number 3 is unclear to me. A sketch could help to clarify.
- Page 39 line 768: Regridding routine is not completely clear to me. Are the averaged pixels weighted by their ratio by which they cover the reference pixel?
- Page 39 line 776: Agreement for summer seems to be worse than for other seasons. The maximum in TROPOMI is seen in the NW, in MAXDOAS it is south.
- Page 39 line 782: Can this be explained?
- Page 39 line 792: Explain SEAS, I guess season?
- Page 40 line 806: "… presented in Dimitropoulou et al. (2020), see table 4."
- Page 41 figure 21: If possible, remove one color bar and use the free space to widen the plots in x-axis.
- Page 44 figure 23: Red line is hardly visible
- Page 45 table 4: Clarify R (seasonal) and s (seasonal). It probably corresponds to SEAS? Are the number of points the number of days or the number of pixels?
- Page 45 line 885: Add name of the improved FRESCO-S cloud retrieval.
- Page 45 line 887: "Fig. 24 (a) and (b) …"
- Page 46 line 910: Using MAX-DOAS profiles as a priori profiles for TROPOMI is suitable for a consistency check of the method. It should not be mistaken to be the "truth".

- Supplement figure S1: Same y-axis for all plots, MLH could be in the title of the individual sub-plots.
- Supplement figure S3: Same color bar for all plots
- Supplement figure S4: Same y-axis, at least for AOD>0, this highlights the differences much stronger