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Discussions

Interactive comment on "Effects of daily meteorology on the interpretation of space-based remote sensing of NO$_2$" *by* Joshua L. Laughner et al.

Anonymous Referee #1

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The manuscript entitled "Effects of daily meteorology on the interpretation of space-based remote sensing of NO2", by Laughner et al., demonstrates the importance of high temporal and spatially generated airmass factors when calculating OMI tropospheric column NO2. From their study, the apriori used for the retrieval comes from the WRF-Chem model and the temporal and spatial resolutions are investigated when calculating the tropospheric column NO2.

Overall, this is a nice study and highlights the some of the limitations in the current publically available NO2 products (i.e. NASA and KNMI). For that reason, the manuscript should be published in ACP with some minor corrections.

Minor comments:

Figure 1 is a very nice example of how the AMF is influenced by monthly and daily aprioris. From the manuscript, the authors suggest that this is based on the prior vertical information of NO2 from the model and the scattering weighting function. However, in the introduction there was no reference to why the AMFs are smaller/larger in the scenarios in Figure 1. I think adding a short explanation of what causes the AMFs to be different would be useful. Also, as far as I can tell, the manuscript doesn't quantify which of the two processes in Eqn 2 & 3 influencing the AMFs are most important. Which is it?

In section 2.5 the EMG is discussed in detail (and in the supplementary information), but often with reference to how Matlab functions are used to calculate the required equations. For someone who has not used Matlab before, this might be difficult to follow (e.g. fmincon, nansum etc). Could the authors just discuss the mathematical and statistical methods used and leave discussion of Matlab functions in the supplementary material? I also think that there should be discussion on what a, x0, μx, σx and B are in the text of section 2.5, instead of just referring to Table 1.

In section 2.3, there is discussion on weighting schemes (i.e. Eqn 5). Unfortunately, I do not understand how and why this is used. If you are trying to calculate the model monthly mean relative to the OMI sampling, could you not just subsample the model to the individual satellite overpass times (e.g. within 1 hour of 14.00LT)? This text (Page 6, Lines 5-10) needs to be improved to make the motivation for Eqn 5 clearer.

In the abstract and introduction any reference to "Atlanta, GA" should be "Atlanta, GA, USA" as not everyone will know Atlanta is in the USA.

On Page 2, Lines 26-27, "Because the satellite is less sensitive to NO2 near the surface, the AMF should be smaller in locations influenced by surface NOx sources" this is discussed in detail throughout the manuscript, but it would be good to add a short sentence here explaining why this is the case.

Page 3, Line 11: BEHR needs to be defined here, not later in the section.

Page 3, Lines 13-14: "2° x 3° and 0.5° x 0.667°". I'm assuming this is lons then lats?

For the statement "Valin et al. (2013) showed that the concentration of NO2 downwind of a city increases significantly with wind speed." on Page 3 Lines 24-25, can a range be provided to which this statement is true.

Page 3, Lines 27-29: The authors should explain why OMI is less sensitive at lower altitudes or provide a reference which explains this.

In the Introduction, we are informed that this study focuses on Atlanta. The reasoning for this is explained later on in the manuscript, but needs to be mentioned here as well to make it clear why this region is the focus of the study.

Please reword Lines 30 (P4) – 2 (P5) to make the text clearer. i.e. "These have been classified as the "row anomaly" and as of 5 July 2011 affect one-third of the pixels http://projects.knmi.nl/omi/research/product/rowanomaly-background.php), reducing coverage from global daily to global every two days".

In the title of section 2.2 please expand out what "BEHR" represents. Also, P5, L5, BEHR doesn't need to be expanded again as it is done so in the Introduction.

In Eqn 2,3 please specifically state what "p" represents. Also, how is ptp defined (e.g. dynamical, chemical tropopause)?

Please provide a reference or explanation why "an assumed cloud albedo of 0.8" is used, on P5 , L 21.

P5 Line 29: What does NE1 11 stand for/represent?

The manuscript should not reference papers in prep such as Zare, (in prep) on P6 Line 4.

P6, L5: Please provide justification for using a spin up period of just 5 days.

P6, L20: Please rephrase ""pseudo-retrieval" that is much simplified compared to a full

operational NO2 retrieval" and outline how it is much simpler. Also on L21, please state some examples of co-founding variables.

Section 2.5: Firstly, I cannot find an example of where EMG is expanded (i.e. what does it stand for)? Secondly it should be expanded in the introduction where EMG is first mentioned. It should also be written in full for the title of this section.

P7 L20: An explanation on why the WRF winds are transformed to earth-relative from grid-relative would be much appreciated.

Eqn 8: Please define specifically what F(x. . ...) represents. Also stating what "erfc" stands for would be useful as well. I'm assuming it is "error function"?

P9, L8-9: As stated above, the reasoning for choosing Atlanta needs to be outlined earlier on in the manuscript.

In Figure 2b, it would be useful to add a scale for the wind speed or add some text to the caption stating what the min, mean and max winds in the domain are for that period.

P9-10, L30-1: Please expand on "All pixels show a positive change." Is this correct. Should there not be negative changes somewhere in the domain?

Please expand VCDs in the section 3.2 title.

P11, L9-11, the authors state that the uncertainty value of 1015 molecules per cm2 can be reduced by a factor of the SQRT(n). However, this assumes that all errors in this uncertainty value are random. Surely, some of the error will be systematic or smoothing errors? Therefore, the authors show take this into account or explain why it can be done like this.

The two sentences on P11, L7-9 "The main decrease around Atlanta is to the northeast, along the direction that the monthly average model results placed the NO2 plume. A systematic decrease of 5–10% to the northeast of Atlanta is observed; this is the

plume direction in the monthly average profiles." need to be reworded as discussing "northeast" twice is repetitive.

Just double checking on P11, L17, this should definitely "southeast"?

P12, L12. Should be "a x0" and not "an x0".

On P13, L14-19, the t-test is discussed to determine if "differences in emissions and lifetimes are significantly different among the results derived from using the three different a-priori profiles....". The t-test assumes that data within the sample population are independent. However, I imagine there will be lots of temporal autocorrelations in the samples. Do the authors account for this and if not, why?

On P14, Lines 3-15, comparisons to the NEI 11 emissions are discussed. From the text, the NE1 11 emissions are overestimated by 50%. If the NEI 11 emissions took this into account, which results (e.g. monthly or daily apriori) which have best agreement with them. Also, on L7, the authors state that the "daily 12 km a priori are within 5-24%". Are they lower or higher than the NEI 11 emissions or both? The authors have stated that the "coarse monthly a priori" are lower by 43-62%.

Supplementary Information:

P1, L16: Why would we expect the mean and median differences to be 0?

P1, L20-22: "This, combined with the greater scattering weights at these altitudes, explains why the effect on the AMF is as large as it is, although day-to-day changes in the boundary layer still dominate the effect using daily profiles has on the AMFs,". The "," at the end of the sentence should be a full stop. Secondly, can the impact of the scattering weights at this altitude be quantified, say in comparison to the impact of the apriori on the AMFs?

P1, L30: Is this period of 91 days long enough for the averaging to have no net impact?

P2, L 9: Should be "Atlanta, nevertheless" or "Atlanta. Nevertheless".

P4, L4-5: Should be these "]" brackets and not ")"?

P5, L20: "as the errors contributing to it should be random in nature". Why is this the case? No systematic errors?

P6, L15: "). nfit"?