Dear Reviewer,

Thanks very much for your comments. We appreciate the time and effort taken to provide valuable comments on this manuscript. We have modified the manuscript accordingly. Below are our responses:

Major comments

Comment_1: *Two of the key error sources the authors discuss are wind direction and wind speed uncertainties. While I agree that wind speed introduces important uncertainties in flux estimates, I think that wind direction at such relatively short distance from a point source can be estimated with reasonable accuracy just from geometry. I strongly disagree with the way the authors have estimated wind uncertainties: They use a statistical evaluation of wind measurements at one site and interpret the standard deviations they find in these measurements as uncertainties which they then parametrise as a function of wind speed. However, this is not the quantity of interest for flux measurements, where wind speed and direction is usually taken from a close-by measurement or a model. I think either the authors need to explain why I am wrong, and this is after all a good representation of the uncertainty of the wind information usually employed in car-DOAS measurements, or they should use another, maybe simpler representation of the wind field uncertainty.*

Response:

Thanks for this suggestion. We agree that of course in general the use of nearby wind measurements would be preferred and errors related to wind field uncertainties should be calculated based on such wind measurements

However, the main aim of our study is to determine the error budget of the total flux and its different contributions in a general way. For that purpose, the parameterization of the wind speed uncertainty is very helpful to derive recommendations about favorable measurement conditions (e.g. wind speeds).

Therefore, we keep the results of the parameterization of wind field uncertainty.

Nevertheless, we agree that wind direction at such relatively short distance from a point source can be estimated with reasonable accuracy just from geometry. Thus the wind direction uncertainty contributes only a small error to the total flux error. We have re-simulated the results, and updated all the results in the manuscript accordingly. We also added a brief discussion into section 2.6 (lines 299-302):

The wind direction uncertainties play a smaller role in point source flux measuring error (and can be derived from geometry), thus the uncertainties caused by the wind field are dominated by the wind speed uncertainties. The error term of the wind direction uncertainty is therefore removed.

Comment_2: *One important discussion point in the manuscript is the sampling error. Unfortunately, even after reading this part several times and checking the referenced papers for an explanation of what exactly this sampling uncertainty is, I was not able to understand it. In an ideal world, where the sky brightness does not change, the instrument has no dead time between measurements, and there are no nonlinear effects in the DOAS evaluation, the retrieved VCDs are the mean VCDs over the distance travelled during the integration time. If the wind field is homogeneous as I assume is the case in this study, then I fail to see where the "sampling error" comes into play. I think the authors need to provide a better explanation of what exactly they are referring to with this term.*

Response:

Thanks for this comment. The sampling resolution error results from the GPS measurement error and the sampling error. In general, GPS errors of neighboring flux contributions almost completely cancel each other. However, for the sampling error, we have added the explanation to the text (lines 389-393):

In actual measurements, if one distance is too long, and this happens to be inside the plume, while the next distance is too short but is already outside the plume, the flux will be overestimated in spite of the fact that the sum of the two distances has only a small error. In this case, the sampling error becomes important. The sampling error is largest when the sampling resolution is large. Thus a small and uniform sampling resolution is particularly important.

Comment_3: *One relevant point of the manuscript is the discussion of the NO_2/NOx ratio on the measurement uncertainty. Maybe I overlooked this information, but it was not clear to me how this uncertainty was computed – did the authors just assume that no correction is applied in the retrievals, so the error is defined as the difference between an assumed steady state ratio and the real NO_2/NOx ratio? Or is the uncertainty only increasing because the NO_2 column is decreasing as one approaches the stack? Please clarify in the manuscript.*

Response:

Thanks for your comment.

We have added more information in section 4.4 (lines 539-552):

In actual measurements, especially for elevated point sources, the dependence of the [NOx]/[NO_2] ratio on the distance from the air parcels of the plume is difficult to measure. The [NOx]/[NO_2] ratio could e.g. be measured by an in situ instrument on the ground. However, in some cases the plume might not reach the ground. And even if it reaches the ground the measured [NOx]/[NO_2] ratio is probably not representative for the whole plume. Furthermore, also the ambient [O_3] could be measured, which would help to constrain the [NOx]/[NO_2] ratio. But also if O_3 measurements are available, the calculation of the [NOx]/[NO_2] ratio will have its uncertainties, and the derived [NOx]/[NO_2] ratio will again not be representative for the whole plume. Thus in our study, we calculate the [NOx]/[NO_2] ratio based on the dispersion model with some additional assumptions which are outlined in the text. In this way we can derive the general dependencies of the [NOx]/[NO_2] ratio on the plume distance and apply a corresponding correction. However, for the NOx flux calculations, even after the application of the [NOx]/[NO_2] ratio correction factor, substantial flux errors near the source might occur.

Comment_4: *I realize that this may be bordering onto a philosophical discussion, but I do not agree with the distinction the authors make between SCD uncertainty and undetectable SCD. In my view, this is two aspects of the same thing as the signal from the "undetectable SCD" is not missing, but just hidden in the noise. If the integration time is increased or more transects through the plume are averaged, then the "undetectable SCD" is reduced. The separation of these two effects may be*

illustrative to explain why measurements should not be done in the far field of the plume, but it is in my opinion not correct to claim that repeating measurements does not decrease the "undetectable SCD" as is stated in the manuscript. In general, I think that adding this as an additional error term is not mathematically correct.

Response:

Thanks for this suggestion. SCD retrieval error consists of a random and a systematic part. The random part mainly comes from the fit error (which tends to cancel out and has only a small contribution the flux error) and the systematic part mainly comes from the error of the trace gas absorption cross-section. The undetectable SCD is the SCD below the SCD detection limit and the detection limit can be estimated to be about 2 times the fit error (Platt and Stutz, 2008). Therefore, the SCD uncertainty mainly includes the undetectable SCD and the SCD error caused by the trace gas cross-section error. These two errors are independent from each other.

We have added a respective discussion on the error of the retrieved SCDs and (including the effects on the detectable flux and the gas absorption cross-section error) accordingly (lines 281-304):

The emission flux measurement errors by mobile DOAS have several sources: SCD fit errors, AMF errors, wind field uncertainties, and sampling resolution measurement errors (Johansson et al., 2008, 2009; Wagner et al., 2010; Ibrahim et al., 2010; Shaiganfar et al., 2011, 2017; Rivera, et al., 2012).

The uncertainty of the derived SCD from the DOAS fit has a random and systematic part. For the random part it can be assumed that in general it cancels out (in combination with the sampling resolution error it can have a very small contribution). Thus, its direct effect on the total flux error is neglected in the following. However, from the fit error also the detection limit is estimated. For SCDs below the mobile DOAS detection limit, undetectable SCDs result in undetectable flux and therefore the fit error indirectly contributes to the total flux error.

The systematic part of the SCD error caused by the uncertainty of the trace gas absorption cross-section is independent from the SCD fit error and is therefore included as an additional term in the total flux error calculation.

We assume that these errors are random, have a Gaussian distribution and are independent of each

other. Then the total relative error of the emission flux is given by:

$$E_{total} = \frac{F_{err}}{D \cdot Q} \times 100\% = \frac{\sqrt{\Delta F_{cro}^2 + \Delta F_{uf}^2 + \Delta F_{AMF}^2 + \Delta F_u^2 + \Delta F_s^2}}{D \cdot Q} \times 100\% \quad (16)$$

where F_{err} is the flux error; ΔF_{cro} is the flux error introduced by gas cross-section error; ΔF_{uf} is the undetectable flux; ΔF_{AMF} is the flux error introduced by AMF errors; ΔF_u is the flux error introduced by wind speed uncertainty. The wind direction uncertainties play a smaller role in point source flux measuring error (and can be derived from geometry), thus the uncertainties caused by the wind field are dominated by the wind speed uncertainties. The error term of the wind direction uncertainty is therefore removed. ΔF_s is the emission flux error introduced by sampling resolution measurement error and it can be neglected (see section 4.1).

We have added discussions on the undetectable flux and gas absorption cross-section error accordingly:

4.5 Undetectable flux

As discussed in sections 4.3, undetectable flux dominates the flux error when far from source. In the following, we discuss further details of the undetectable flux error. The undetectable flux is caused by SCDs below the detection limit. Following Platt and Stutz (2008), we set the detection limit as 2 times the fit error. While the exact value of the detection limit might be different for different instruments and measurement conditions, we use this value to derive the general dependencies of this error term and its contribution to the total flux error.

VCDs are sensitive to wind speeds and the dispersion (Eqs. 9 and 10), so is the undetectable flux. We calculate the undetectable flux and its R_{uf}^2 along wind direction (equal to along the measuring distance) as shown in Figure 14 (for an emission rate of 100 g/s). As discussed, the main driver of undetectable flux increasing trend along the wind direction is attributed to the wind dispersion as can be seen from Figure 14. With measuring distance far away, the undetectable flux gradually dominates the flux error which can be denoted by R_{uf}^2 trend. Large wind speed also results in quick dispersion

thus leads more undetectable flux. The R^2_{uf} and the undetectable flux increases rapidly under the wind speed of 8 m/s than that of 1.2 m/s for both NOx and SO_2.

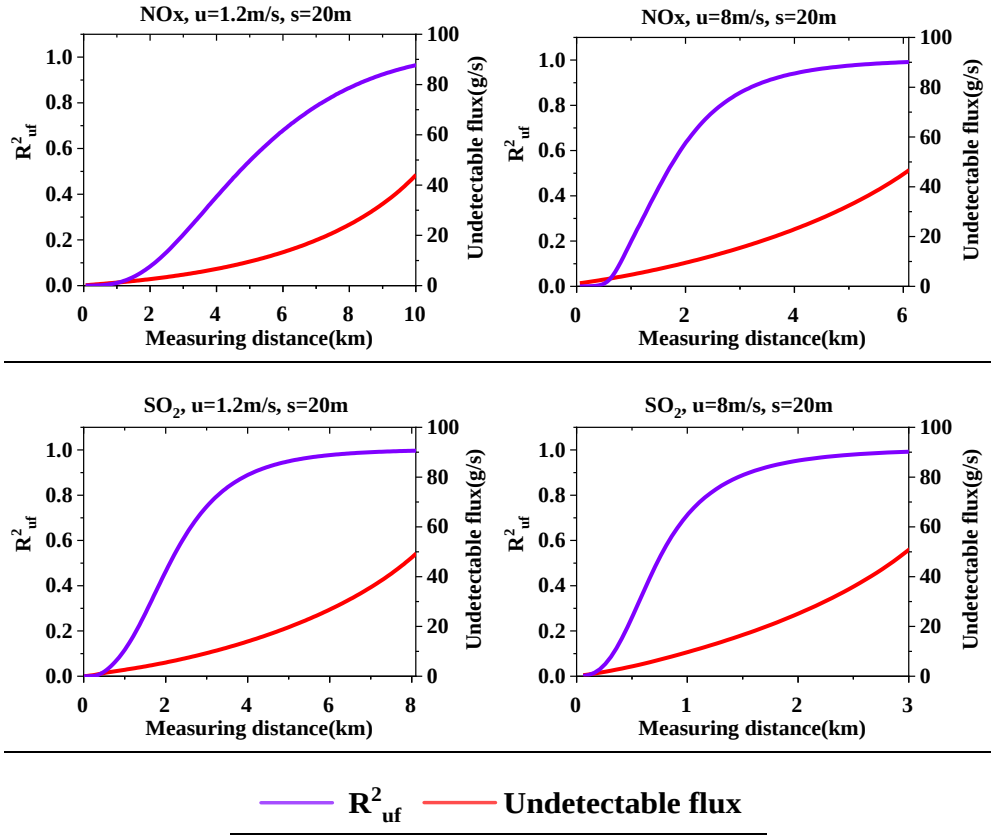

Figure 14. NOx and SO_2 absolute flux error, and the R^2_{uf} that SCD uncertainties resulting in (Q = 100 g/s)

4.6 Gas absorption cross-section error

As discussed in section 2.6, the gas absorption cross-section error contribution to SCD errors is independent of the SCD fit error. Uncertainties of the trace gas cross-sections cause systematic SCD uncertainty. We calculated R^2_{cro} along the wind direction and the total relative errors at the speed of 1.2m/s and 8m/s, as shown in Figure 15. The R^2_{cro} variation trend is similar to R^2_{uf} in section 4.6 due to the relative error variation. However, maximum R^2_{cro} has subtle difference but varies apparently along the wind direction under different wind speed, which indicates that R^2_{cro} is not very sensitive to wind speeds but sensitive to the dispersion. From Figure 15 we see that R^2_{cro} could approach 0.5, which means that gas cross-section error might even become the main error source.

However, when R^2_{cro} is close to 0.5, the relative errors of NOx and SO_2 are at low levels. This further suggests the trace gas cross-section error has an overall small contribution to the total flux error.

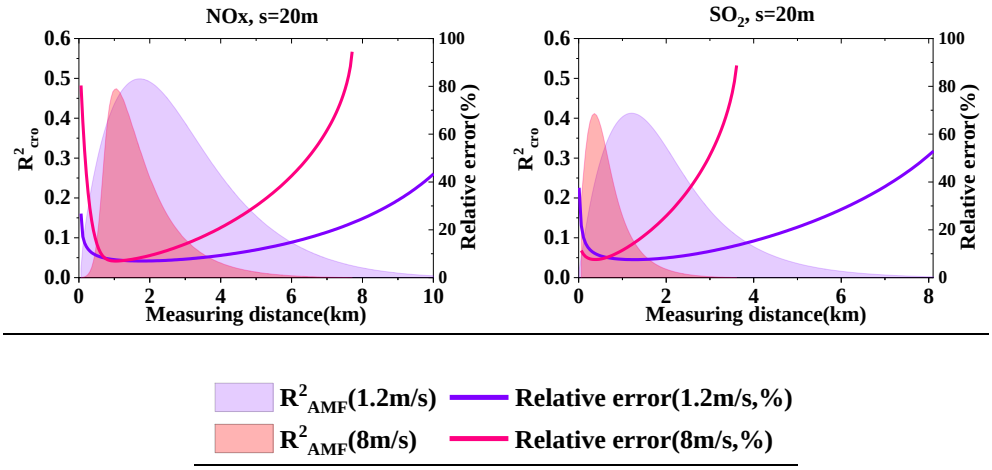

Figure 15. NOx and SO_2 R^2_{cro} of absorption cross-section error under different wind speed (Q = 100 g/s)

Comment_5: *The authors took a "top-down" approach for this manuscript, showing simulation results and then explaining them. While I understand that this is how science often works, it does not necessarily help in making the manuscript focused and revealing the underlying physical effects. In my opinion, a "bottom-up" approach explaining the key effects (such as dependence of VCD on wind speed, NOx/NO_2 ratio on time since emission, sampling error on measurement distance) and then illustrating it in the simulation results.*

Response:

Many thanks for this comment. This study aims to offer recommendations for the optimum settings of mobile DOAS measurements. Therefore, a universal and complete approach is very important. Nevertheless, we have added "*a 'bottom-up' approach explaining the key effects*" at the beginning of section 2.6(lines 270-280):

Emission flux measurements errors not only arise from measurement errors but also depend on other factors, such as wind speed, measuring distance, [NOx]/[NO_2] ratio and the sampling resolution.

Since the VCD is inversely proportional to the wind speed (Eqs.9 and 10), the higher the wind

speed is, the lower the VCD. This means more measurements at the edge of plume would be under the detection limit at higher wind speeds causing more undetectable flux. The VCD is also inversely proportional to measuring distance (Eqs.9 and 10). This means that the undetectable flux increase with measuring distance. Since the [NOx]/[NO_2] ratio depends on the measuring distance (see figure 10), a large [NOx]/[NO_2] ratio correction error occurs when the measuring distance is small. Finally, the sampling error can be reduced with improved sampling resolution.

Comment_6: *Overall, the manuscript would benefit from detailed proof reading. In some parts, in particular the description of the plume modelling, it is difficult to follow because of the use of English. In response to a suggestion from the quick-look review, the authors have in part introduced "air parcel" where they used "plume" before, but that did unfortunately not help to clarify this section. I hope that this section can be made clearer. Also, the use of "ambient SCD" is confusing and should be replaced by another formulation, maybe simply SCD.*

Response:

Thanks for the suggestion and we have revised the manuscript accordingly. We have introduced air parcel in many other places, and also substituted "SCD" for "ambient SCD".

To introduce the air parcel, we have also added at the following text at the beginning of section 2.1 (lines 107-109):

(2) The plume is diluted by the wind along the wind direction (*x* axis). The random movement of air parcels dilute the plume also in the cross-section and in the vertical directions (*y* axis and *z* axis).

We also tried to improve the use of the English language.

Detailed comments

Comment_1: *Abstract: Too long, please just summarize the main points instead of giving a detailed account of the study.*

Response: We have changed accordingly and it is:

Mobile differential optical absorption spectroscopy (mobile DOAS) has become an important tool

for the quantification of emission sources, including point sources (e.g., individual power plants) and area emitters (e.g., entire cities). In this study, we focused on the error budget of mobile DOAS measurements from point sources, and we also offered recommendations for the optimum settings of such measurements via a simulation with modified Gaussian plume model. Following the analysis, we conclude that: **(1)** The proper sampling resolution should be between 5 m and 50 m. **(2)** When measuring far from the source, undetectable flux (measured SCDs are under the detection limit) resulting by wind dispersion is the main error source. The threshold for the undetectable flux can be lowered by larger integration time. When measuring close to the source, low sampling frequency results in large errors and wind field uncertainty becomes the main error source of SO_2 flux (for NOx this error also increases, but other error sources dominate). More measurements times can lower the flux error that results from wind field uncertainty. The proper wind speed for mobile DOAS measurements is between 1 m/s and 4 m/s. **(3)** The remaining errors by [NOx]/[NO_2] ratio correction can be significant when measuring very close. To minimize the [NOx]/[NO_2] ratio correction error, we recommend minimum distances from the source, at which 5% of the NO_2 maximum reaction rate is reached and thus NOx steady-state can be assumed. **(4)** Our study suggests that emission rates < 30 g/s for NOx and < 50 g/s for SO_2 are not recommended for mobile DOAS measurements.

Based on the model simulations our study indicates that mobile DOAS measurements are a very well suited tool to quantify point source emissions. The results of our sensitivity studies are important to make optimum use of such measurements.

Comment_2: *Somewhere you should have a brief discussion of those aspects of the measurements which also lead to errors, but are not treated in this study, for example stratospheric correction, uncertainty in background measurement, non-Gaussian behavior of plume, vertical wind shear, …*

Response:

Thanks for this suggestion. We have added a brief discussion into the section 4.10.3 (lines 837-843):

The Gaussian dispersion model was assumed in the forward model during our discussion of the emission flux error budget. The dispersion in actual measurements, however, depends on

meteorological conditions and surrounding terrain. Also a non-Gaussian behavior of the plume and vertical wind shear might contribute to the total flux error. Thus, the results of this study should be seen as a lower limit of the total flux errors. In some cases, for NO_2, also the stratospheric absorption might become important. However, this might only happen for very long measurement durations or for measurements at high SZA.

Comment_3: *Section 2: I think it would be good to have a brief description of flux derivation with car-DOAS measurements first to remind all readers of how this is done and what the relevant quantities are. Later in this section, one could then refer to this introduction.*

Response:

We have moved some parts from section 2.5 to the beginning of section 2.1(lines 93-100):

The NOx and SO_2 emission flux of the point source can be well measured by the mobile DOAS. The equation for calculating the emission flux in the discrete form is expressed as

$$F = \sum_j VCD_j \cdot \overrightarrow{u_j} \cdot \vec{n}_j \cdot s_j \quad (1)$$

where F is the emission flux; $VCD_j = SCD_j / AMF_j$, SCD_j is the SCD for mobile DOAS measurements along the measurement route; AMF_j is the Air Mass Factor; $\vec{u}_j$ is the wind field; $\vec{n}_j$ is the vector pointing to the right of the driving direction and parallel to the Earth's surface; and s_j is the sampling resolution. For an isolated point source, the mobile DOAS can measure underneath the plume in downwind direction to quantify the emission flux.

Comment_4: *Section 2.1: The wording here is in parts confusing – "emission flux simulation" should be "simulation of emission flux measurement" as it is not the emission flux itself which is simulated.*

Response:

We have changed it to "simulation of emission flux measurement" and also in figure 2.

Comment_5: *Table 2: I'd suggest to remove those cases which are not use in this work (D, E, F)*

Response: We agree. We have removed these cases.

Comment_6: *Lines 175 – 183: I'm confused by this part which suggests that some temporal variations of the wind field need to be taken into account. However, as far as I understand the simulations, this is not the case. Please clarify and if this is not used in the simulations, please remove it.*

Response: We agree. We have removed it.

Comment_7: *Section 2.2.2: Please re-read carefully and make clear where you talk about the whole plume, a transect of the plume or an air parcel within the plume. For example, in line 200 you write "[O_3] is the mean concentration in the plume at time t" but in a static model as I assume you have, there are no changes with time. I assume in this case you are talking about the [O_3] in an individual air parcel moving through the plume. In line 208, you write "For simplicity, we assumed that the O_3 concentration within the air parcel of the plume is the same everywhere", but I assume that you mean that [O_3] is the same on a transect of the plume.*

Response:

Thanks for this correction. We have moved the sentences (original lines 206-209) here and revised accordingly (lines 205- 209):

where [gas] stands for the concentration of a particular gas; $[O_3]_t$ is the O_3 concentration in the air parcels of the plume at time *t; t* is the time period after NOx is emitted into the atmosphere. We assumed that at the beginning there is no O_3 in the air parcels of the plume. During the mixing with outside air, the O_3 concentration within the air parcels increases. For simplicity, we assumed that the O_3 concentration is the same everywhere in a transect of the plume.

Comment_8: *Section 2.2.2: In my opinion, additional assumptions were made in this section which should be mentioned, in particular that no NOx is present in ambient air as otherwise this would be mixed into the plume and more importantly, that no O_3 is consumed in the reaction with NO (which is clearly not correct). Please add this to the discussion.*

Response:

Thanks for this advice. We have added the following text to the discussion into subsection 2.2.2 (lines 190-197):

In this study, we did not take Volatile Organic Compounds (VOCs) into consideration; thus, a NOx balance would not be broken. Moreover, we assume that no NOx is presented in the ambient air and no O_3 is consumed in the reaction with NO. In most cases, both assumptions are reasonable, especially as long as the background NOx concentration has no strong spatial-temporal variation. However, for very high emission rates, the assumption that no O_3 is consumed in the reaction with NO might be violated (a simple criterion to identify such cases might be to check whether the NOx mixing ratios are higher than the ambient O_3 mixing ratios). If this is the case, the conversion of NO to NO_2 will be delayed.

Comment_9: *Equation 12: I think it would be good to explicitly show the dependence of R_{NOx} on (x) here.*

Response:

Thank you for advice. We have added a sentence to explicitly show the dependence of R_{NOx} on (x) (lines 243-245) and it is:

Since NOx disperses along the wind direction and R_{NOx} is a function of *t*, this means that R_{NOx} also varies with distance. The detailed relationship between the distance and R_{NOx} will be discussed in subsection 4.4.

Comment_10: *Equation 13: Please introduce $\triangle F$ and l. Do you assume that there is no NO2 or SO2 outside the plume?*

Response:

We have introduced $\triangle F$ *and l* accordingly (lines 251-252):

ΔF_j is the flux along the measurement route *l* in theory. For mobile DOAS measurements, ΔF_j should be given by Eq. (13).

We assumed that there is no NO_2 or SO_2 outside the plume and we have modified the assumption (3) in section 2.2 (lines 110-112):

(3) The topography around the point source is flat and the background concentration of the pollutants is regarded as zero. In case of non-negligible background concentrations, the VCDs in the plume have to be calculated as difference to the background.

Comment_11: *Equation 14: For clarity, $\triangle F$ and s should also have an index j here.*

Response:

Thanks for this suggestion. We have added the index *j to* $\triangle F$ and *s*.

Comment_12: *Equation 16: Why do you change notation here for the inner product? Why is the index now i and no longer j ?*

Response:

Thanks for this comment. We have unified the indexes as *j* from these equations.

Comment_13: *Equation 18: In order to be able to write the total error in this way, you need to assume that the errors are random, have a Gaussian distribution and are independent of each other. Is that a reasonable assumption?*

Response:

Thanks for this advice. It is a reasonable assumption and we have added this assumption before this equation (lines 294-295, please also refer to the response to major Comment_4).

Comment_14: *Equation 18: Why is Q used here instead of F ?*

Response:

For a plume cross section at a given distance, the flux (*DQ* in Equation 18) includes the detectable flux (*F*) and the undetectable flux($\triangle F_{uf}$) in theory. When the measuring distance is close to the source, $DQ \approx F$. However, this is not true when far from the source. Therefore, using *DQ* here is more reasonable and reprensentive, and this also ensures the consistency of the error evaluation

criteria.

Comment_15: *Line 310: I agree that GPS errors tend to cancel, but this is not necessarily true for flux errors. If one distance is too long, and this happens to be inside the plume, while the next distance is too short but is already outside the plume, the flux will be overestimated in spite of the fact that the sum of the two distances has only a small error.*

Response:

Thanks for this comment and we agree. This is the sampling error. This scenario can indeed become important in actual measurements. In this case, a relatively small and uniform sampling resolution is particularly important. That is another reason that we only recommended the sampling resolution 5~50m, and this recommendation is also to minimize a potential flux overestimation. We have added a brief discussion of this scenario into the section. (lines 389-393):

In actual measurements, if one distance is too long, and this happens to be inside the plume, while the next distance is too short but is already outside the plume, the flux will be overestimated in spite of the fact that the sum of the two distances has only a small error. In this case, the sampling error becomes important. The sampling error is largest when the sampling resolution is large. Thus a small and uniform sampling resolution is particularly important.

Comment_16: *Section 4.3.1.1: There is also the effect of the plume width decreasing with increasing wind speed which counteracts the effect of increasing "undetectable SCD".*

Response:

We agree. The plume width we referred here is the width that can be detected by mobile DOAS. As the SCD is inversely proportional to the wind speed, this results in lower SCD under large wind speed and the "detectable SCD" decreases.

Comment_17: *Line 498: I understand the idea of the authors that if NOx is in steady state, it is easy to compute the NO_2/NOx ratio. However, at least in principle, one can estimate the NO_2/NOx ratio from the ambient O_3 concentration, the wind speed and the distance from the source as explained*

earlier in the manuscript.

Response:

We agree that one can estimate the NO_2/NOx ratio from the ambient O_3 concentration in principle. In actual measurement, it is hard to estimate the NO_2/NOx ratio along the distance from the ambient O_3 concentration, the wind speed and the distance, although it is easy to realize in the simulation.

Comment_18: *Line 542: I don't think that this estimate is really conservative as two assumption son the NO to NO_2 conversion were made which both go into the direction of too fast conversion: 1) instantaneous mixing of O_3 into the plume and 2) no consumption of O_3 in the reaction with NO. In reality, the center of the plume will have lower O_3 than the outer parts and O_3 levels will be generally lower than in the ambient because of the high NO concentration inside the plume.*

Response:

We agree that and we have removed this discussion accordingly.

Comment_19: *Line 554 and following: It is still not clear to me why the absolute retrieval error decreases at large distance. This is counterintuitive to me.*

Response:

Thanks for this comment. The retrieval error here we referred is the DOAS fit error (we have revised 'retrieval error' as 'fit error' in the manuscript). When at larger distance, the flux error caused by SCD fit error decreases. We have removed section 4.5 (original title: **4.5 Retrieval error**) and please refer to the response to major comment_4.

Comment_20: *Figure 14: I do not understand why absolute flux retrieval errors are shown here – relative errors (not R2 but relative errors of the total flux) would be easier to understand.*

Response:

Thanks for this comment. We have removed section 4.5 (original title: **4.5 Retrieval error**). Please refer to the response to detailed comment_19.

Comment_21: *Line 574: As discussed above, I disagree with the statement that the undetectable flux cannot be reduced by multiple measurements.*

Response:

We agree that the undetectable flux can be reduced by multiple measurements. However, in reality this is often not possible because it requires that all measurement conditions (e.g. the wind field or the background concentrations) stay unchanged. This means that the undetectable flux is hard to be lowered by more time scanning in the actual measurements, although it can be easily realized in theory. Therefore, we regard the undetectable flux as the second error source, and in reality, it is difficult to reduce it by multiple measurements. We have added the following discussion on this to the text (lines 678-688):

The error sources of the emission flux can be classified into 2 types. The first is the measurable error/uncertainty: wind speed uncertainty, AMF error and undetectable flux. The second is: [NOx]/[NO_2] ratio correction error near the source and the gas absorption cross-section error. The flux error resulting from the first type of error source can be lowered by scanning the plume more times while the second cannot. Undetectable SCDs result in undetectable flux, and it can be reduced by more measurements times in theory. In reality, this is often not possible because it requires that all measurement conditions (e.g. the wind field or the background concentrations) stay unchanged. This means that the undetectable flux is hard to be lowered by more time scanning in the actual measurements, although it can be easily realized in theory. Therefore, in practice also the undetectable flux error belongs to the second type of errors, which cannot be reduced by multiple measurements.

Comment_22: *Figure 19: As Figure 14 – why absolute instead of relative flux errors?*

Response:

Absolute flux errors could help to understand the main driver of the total flux errors. The causes of the total relative error differences at a prescribed sampling resolution have been analyzed in subsection 4.9.1 (the original is 4.7.1) and it is not necessary to show absolute flux error again. We

have therefore removed the absolute relative flux errors and revised the analysis accordingly.

Comment_23: *Line 701: Why do lower emission rates lead to variations in plume width? In relative units, this should not be the case.*

Response:

The plume width in this manuscript is referring to the width that mobile DOAS could detect. Lower emission rates lead to lower VCDs and to more measurements at edge of the plume below the detection limit. Thus, "lower emission rates lead to a reduction of the measurable plume width".

We have clarified the plume width (lines 806-808):

From Eqs. (9), (10), and (11) we know that the VCD(x,y) is proportional to the emission rate, which means that lower emission rates generate lower VCD(x,y), leading to a reduction of the measurable plume width with SCDs above the detection limit.

Comment_24: *Line 787: Which missing error source are you referring to?*

Response:

Thanks for this comment. The "missing error source" is not a good expression in the manuscript but we missed revising it during the revision process. We have removed it.

Thank you for taking care of our manuscript.

Kind regards,

Yeyuan Huang, on behalf of all authors.