This manuscripts deals with airbone-based remote sensing data to characterize NO2 and HONO pumes from the Sheridan Fire. It uses auxiliary data also coming from airborne-based data, but also from satellite-based data. The exponentially modified gaussian (EMG) approach is used to extract the lifetimes and the emission rates from the NO2 and HONO emissions. Simulations regarding different plume cases are used to understand the limitations of the EMGs. A new methodology based on this very same approach is proposed, which results in a more consistent fit to the plume line densities. Comparison to the daily mean emissions of HONO and NO2 are also carried out. An important point of this manuscript is definitely the transfer of techniques developed in this work to geostationary space-based instruments such as TEMPO and GEMS, which can provide data with a very high temporal resolution.

I want to congratulate the authors for the enormous amount of work related to this manuscript. I also think the English is good, with almost no typos. Regarding the text, there are several comments on this document asking for more clarity. Some times it was difficult to keep up with the text, which made it difficult to read at some points. This also alludes to the science part, where there are some key concepts that were difficult for me to follow.

I consider this manuscript as an added-value to science that meets most quality standards. However, I believe that this work needs some corrections before publication, mostly for clarification. I have separated these corrections into ‘major comments’ and ‘minor comments’.

## Major comments

· Tests have been done using an airborne instrument. However, TEMPO and GEMS are space-based instruments. These instruments appear in the abstract and conclusions, and sometimes in the rest of the test. Regarding their importance for the future, it would be suitable to briefly explain how features as a different spatial resolution would affect the methodologies explain in this manuscript.

· Other methodologies for the estimation of emission rate the NO2 and HONO plumes can provide better results? Please, consider (for example) the IME method and the Cross Sectional Flux method. Maybe these methodology can suffer from incomplete plumes. However, due to the larger swath from space-based instruments, these instruments will be capable to capture entire plumes. As one of the most important points of this study is show the implementation of methodologies on airborne data to transfer them to satellite-based data in the future, it is important to deal with these questions.

· L375-383: A fit with higher R2 guarantees the most accurate values of lifetime and emission? I think it has more to do with the shape of the line density. If it has a gaussian shape it would be very suitable for the fit, but if not, then you can only try to make the best you can. What is then the meaning of the values with the maximum R2? Please, consider to develop more this concept.

## Minor comments

### General comments

· Please, check the acronym definitions and once the acronym is defined, used it. There are several cases in the text that are lately defined or where the acronym is not used.

· Please, make sure that the references to websites are correctly cited.

· Please, avoid unnecessary repetitions along the text.

**Abstract**:

· L22: Are these magnitudes really comparable? See comments later in the text.

1. **Introduction**:

· L35: Is this study only important for the US? If not, please consider to include a more global view in this sentence.

· L39: Regarding GFED and other inventories, the burned area is obtained from satellite-based measurements. Typically, a bottom-up approach is associated with ground-based, local, or detailed data collection at specific sites or sources (such as factories, vehicles, etc.). However, satellite data is more commonly associated with a top-down approach, where broad, large-scale observations (e.g., of emissions, land cover, or atmospheric concentrations) are made, and then models or algorithms are used to estimate emissions, trends, or impacts at finer scales. Please, consider checking the terminology of these approaches.

· L40: ‘as a proxy for amount of material burned’… Please, try to avoid repetition for a more compact writing

· L55-56: Please, include references related to this statement.

· L78-79: Please, consider rewording this sentence for more clarity.

2. **Data and methods**

2.1. **FIREX-AQ**

· The section name refers to the FIREX-AQ campaign. However, the GCAS technical features, the AMF concept, the retrieval methodology and the a priori data are also explained. Please, consider to use different sections to describe the campaign and the methodology-related topics.

· L90: Is the second also measuring 'absolute nadir radiance'? Please, clarify.

· L93: A reference here for these instruments would be suitable.

· L93: Please, explain briefly in which aspects these instruments are similar.

· L98: The GCAS instrument measures radiance, from which the differential absorption spectra from a gas is deduced. Therefore, the different absorption spectra is not measured, but deduced. Then, I would consider removing the term 'measured'.

· L100: A figure showing an example of transmissivity spectra from NO2 and HONO would be illustrative to justify the selection of these fitting windows. Another option could be cite other works that used them.

·L105: AMF is not only dependent of the wavelength and altitude (first sentence), but also dependent of the solar zenith angle and the viewing zenith angle, among others. You refer to these parameters by mentioning the observation geometry (second sentence). However, consider rewording these sentences to build a more compact sentence where the dependencies of the AMF are not split in 2 sentences. It is not wrong, but I think this correction can provide more consistency in the AMF description.

· L108: Please, include a reference for VLIDORT.

· L132: Which is the range of the plume altitude? Is there such a big difference that can have an impact on the results or the selected value is well-suited for this purpose? For example, at different altitude values from the same plume, is there a significant difference in the preassure values? Please, justify the assumption taken regarding the altitude.

2.2. **ERA5**

· L138: Please, consider to show the pressure ranges presenting first the lower values and then the higher values.

2.3. **GOES FRP**

· L145: When reading this sentence, it seems that the main goal from these satellites are to locate fires. Please, consider rewording.

· L149: What is GeoMAC? Please, provide some clarification or at least a reference.

2.4. **Emission inventories**

· L159: In previous text, the angular degree unit was deg. Please, use just one of these units for consistency.

· L160: This sentences is something misleading. Then, this model can provide emission data for NO and HONO or only for NO? Regarding the way it is written, it seems that it says that HONO is a NOx, but it is not.

· L165: Which are the E units? Please, clarify.

· L170-173: Please, consider a simpler description.

· L185: Which are the data sources from GFASv1.2? All the data sources from the previous inventories were described.

2.5. **Analysis methods**

2.5.1. **Calculation of HONO and NO2 line densities**

· L196: This can work for gaussian plume shapes as the ones you show in this study. However, if the direction of the plume is extracted from the plume shape, it will not always align with the wind direction. Please, consider this for the discussion.

· L196: Time averaged VCD plume? Please, clarify.

· Figure 1: 2 of these panels are already shown in Figure 2. You could consider remove them from here or from Figure 1. If you keep the panels from this figure, you can allude to Figure 1 to refer to the track 14 results.

· Figure 1: Please, consider a more compact caption.

· L206: trackS

· Appendix A: In my opinion, it is very difficult to understand this. Please, consider rewording to solve this.

· Appendix A: Please, consider to add some text in this appendix for clarification.

2.5.2. **Exponentially Modified Gaussian (EMG)**

· L217: NOx = NO + NO2. Then, NO2 repeated?

3. **Results and discussion**

3.1. **HONO and NO2 plume structure in the Sheridan Fire**

· Why there is a better resolution for NO2 maps? Please, clarify.

· L264-265: ‘... in all three overpasses, HONO and NO2 share local maxima, plume edges, and plume shape’. Please, consider a discussion about this result. What does this mean?

### 3.2. **EMG emission rates and lifetimes from the Sheridan Fire**

· L274: I would avoid to use the term 'step function' when you are referring to the extracted line densities as they are not extracted according to a known function. Please, consider to use other terms as 'drop sharply' or similar.

· L291-293: This sentence is somewhat confusing in expressing the timeline of events. Please, consider to reword this.

· L294: You could avoid to refer to Fig. 3f if you are already alluded to 'track 14'.

· L301: If you show the ratio of emission rates, you should first calculate them individually. Please, consider to include this calculation in the text (or if not, in an appendix).

· L301: What do you mean with 'similar sampling biases'? Please, clarify.

· L303: ‘... less HONO is being emitted than NO2.…’ Is this correct? As a I understand, it makes more sense to me 'a relative decrease of HONO in reference to previous values' instead of 'less HONO is being emitted than NO2'. 'less HONO is being emitted than NO2' is always true as the ratio is lower than 1. Please, clarify.

· L306: As I understand, constant emission factor ratios should lead to constant emission ratios. To make this clear, I would change here 'emission factor ratio' to 'emission ratio'.

· Figure 4: How you can extract the emission rates of HONO and NO2 from 7 points (Figure 4) regarding that you only have 3 plumes (3 tracks) (L204-207)

### 3.3. **An improved EMG methodology: Monte Carlo diurnal 1-D models**

· L353-355: Please, add a reference related to this idea. Why an increase of thermal ouput lead to an underestimation of the emission rate? Please, clarify.

· L378: From which time? Please, clarify.

· L375-383: As I understand, here you are refering to the 4th PECAN 1-D configuration. Please, clarify this in the text.

· L378: See above where? Please, clarify.

· L379: Where are these ranges coming from exactly?

· L3979: As written here, it seems that the lifetime is also included in the division. Please, consider to reword this sentence to better readability.

· L375-383: Please, specify at which data this exercise is going to be applied.

· L381: PECANS

· L375-L383: This paragraph needs further improvement as it deals with complex concepts that need some clarification.

· L385: Here, the plotted value is R2. You could say that, regarding a R2 value, you could find that it is approximately constant in a combination of lifetime and emission rate values that follow an inverse relationship. However, you cannot say that 'the emission rate has an inverse relationship with lifetime'. Please, reword this sentence.

· Figure 6: Why are two y-axis showing the emission rate in two different units? Please, consider just using one and write to the relation between these 2 units in the text (if needed).

· Figure 6: There are 2 colorbars that are representing the same value. Please, consider to keep only one.

· L400: Which are the input values from the TUV Quick Calculator? Please, clarify.

· L424-426: What does this mean? A presence of a large source of RO2 is realistic? If it is not, what you can say about it? Looking at the plume from Figure A1, it can be seen that there is some influence from the surface. Can the surface have an impact on the retrieval and therefore in the lifetime? Please, clarify.

3.4. **Biomass burning emission inventories underestimate observationally constrained emission estimates**

· L434: Please, consider previous comments regarding the bottom-up and top-down approaches.

· Figure 7: In this section, you deal with the minimum and maximum values of emission rate extracted from track #12 and #14 as representative of the whole day. You called them as 'daily emission rate', which is not true because it does not consider the emission rate at different times during the day. Please, consider to change the terminology and to develop a discussion with this change. Stating that there are biases in reference to daily mean emission from inventories can be misleading.