

## Reply to reviewers' comments

Manuscript ID: atmosphere-918040

Title: Traffic-Related Airborne VOC Profiles Variation on Road sites and Residential Area within a Microscale in Urban Area at southern Taiwan

### Reviewer 1

There are two major suggestions that I think can make this paper more readable and publishable.

First, in Results and Discussion, the authors mostly focused on simply reporting the concentration of various species, instead of any in-depth discussion and reasoning on those numbers. The manuscript will benefit substantially if the authors strengthen the discussions.

**Response:** Thank you for your comments. We have revised the manuscript thoroughly.

Second, the paper did not mention the possible influences from the VOC profiles they measured on ozone products. While the NO<sub>x</sub> measurements may not be available in this study, secondary chemistry from the VOC-NO<sub>x</sub> relationship and the production of ozone represent one of the most important issues in urban air quality and health effects. Including some discussion in the paper will be appreciated.

**Response:** Thank you for your comments. We have explained the role of NO<sub>x</sub> in the photochemical reactions in atmosphere.

### 3.2 Ozone formation potential

Ozone-precursors are related to the NO<sub>x</sub> and VOCs, both precursors effect on ozone formation are different to the locations, and often very uncertain depending on the emission and meteorology (Sillman, 1999). In this study, VOCs effects on ozone formation are evaluated road sites and residential area in urban area.

Maximum incremental reactivity factors (Carter, 2009) were calculated to determine the ozone formation potential (OFP) of VOCs for ambient air at both the roadside and block test sites. The OFP values in the ambient air of a total of 87 VOCs were 682-2233 ng-O<sub>3</sub>·m<sup>-3</sup> for the average different sampling period. The OFP was significantly higher during the rush hours (2233 and 1782 ng-O<sub>3</sub>·m<sup>-3</sup> for the morning and night, respectively) and a low OFP was determined during the non-rush hours.

The OFP fraction profile was similar for different sampling times, with 3.6-5.1% for halogenated, 11-13% alkanes, 17-21% for alkenes, 52-60% for aromatics, and 5.2-9.7% for oxygenated/nitro species (shown as Figure 3).

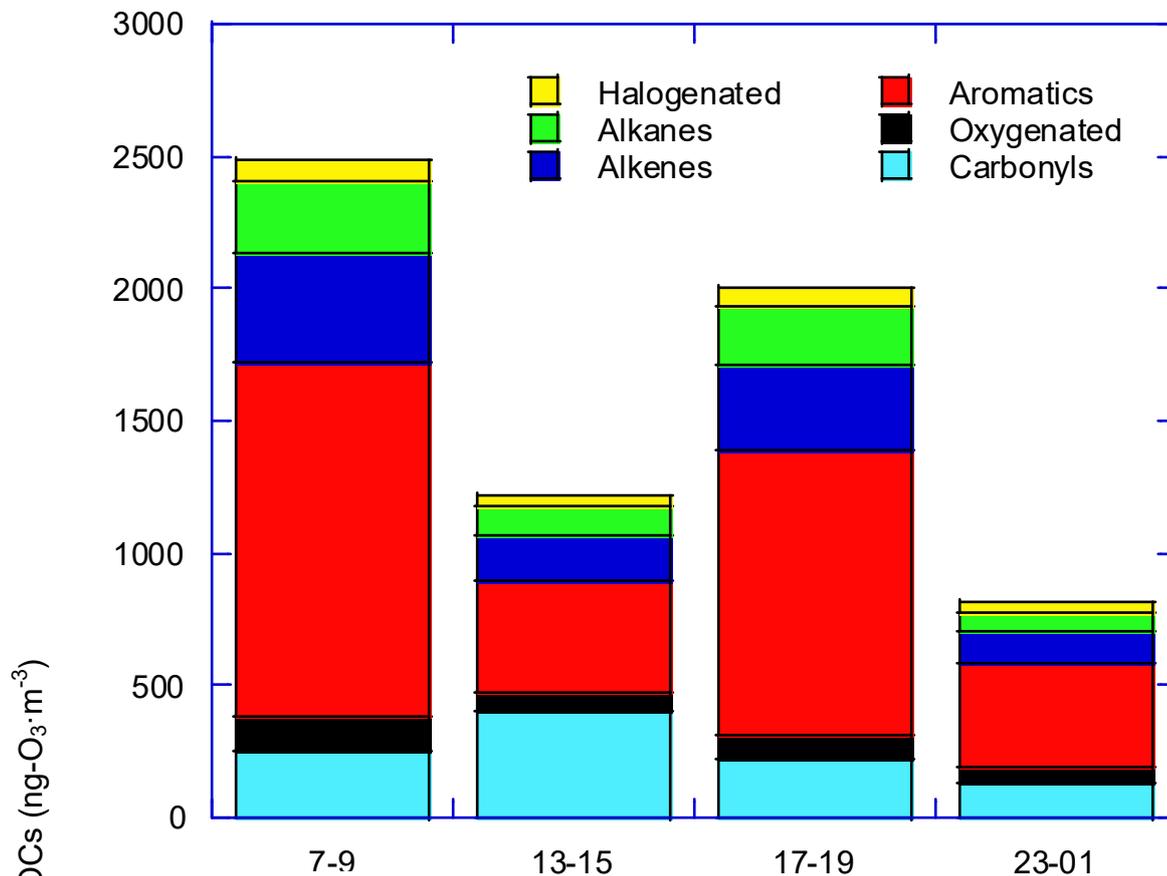
For aromatic species, the high-OFP species were xylene (94-363 ng-O<sub>3</sub>·m<sup>-3</sup> for m,p-xylene and 38-158 ng-O<sub>3</sub>·m<sup>-3</sup> for o-xylene), toluene (85-247 ng-O<sub>3</sub>·m<sup>-3</sup>), 1,2,4-trimethylbenzene (40-185 ng-O<sub>3</sub>·m<sup>-3</sup>), and ethyltoluene (19-102 ng-O<sub>3</sub>·m<sup>-3</sup>, with about 70% attributed to m-ethyltoluene), and 1,3,5-trimethylbenzene (15-74 ng-O<sub>3</sub>·m<sup>-3</sup>).

The OFP of most alkanes was less than 40 ng-O<sub>3</sub>·m<sup>-3</sup>. Methylcyclopentane, 2-Methylpentane, n-pentane, and 2,2,4-trimethylpentane were the major OFP alkane species. Trans-2-pentene (26-103 ng-O<sub>3</sub>·m<sup>-3</sup>), trans-2-butene (35-102 ng-O<sub>3</sub>·m<sup>-3</sup>), 1,3-Butadiene (23-84 ng-O<sub>3</sub>·m<sup>-3</sup>), and cis-2-butene (21-65 ng-O<sub>3</sub>·m<sup>-3</sup>) were high-OFP alkene species.

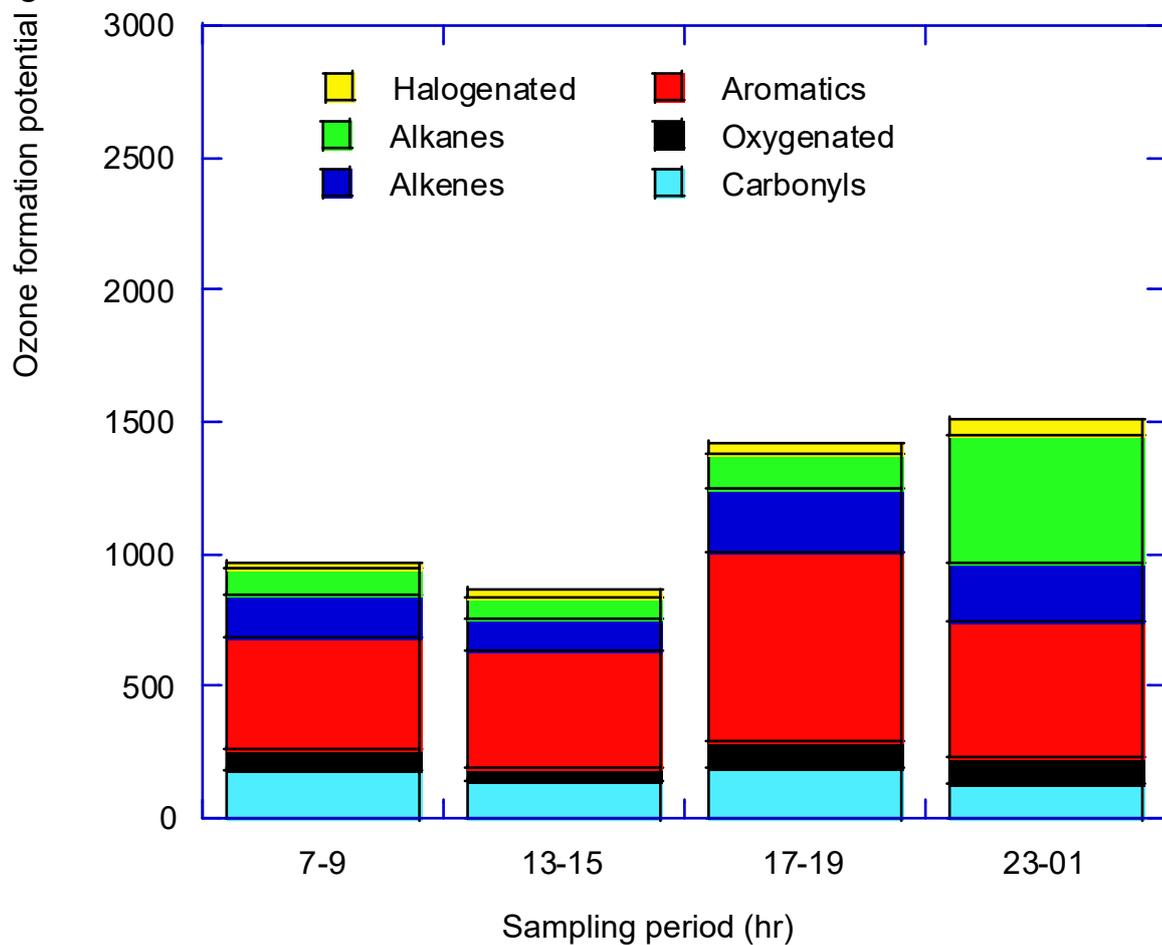
Formaldehyde and acetaldehyde contributed in the range of 33-116 and 44-111 ng-O<sub>3</sub>·m<sup>-3</sup>, respectively, for the different sampling periods. The sequence of OFP of VOCs was rush hour at night (1013 ng-O<sub>3</sub>·m<sup>-3</sup>) ≈ midnight (1006 ng-O<sub>3</sub>·m<sup>-3</sup>) > rush hour in the morning (622 ng-O<sub>3</sub>·m<sup>-3</sup>) > non-rush hour at noon (591 ng-O<sub>3</sub>·m<sup>-3</sup>). The OFP of VOCs was lower at the back sites in comparison with the road sites, except in the midnight air sample.

Sillman, S., The relation between ozone, NO<sub>x</sub> and hydrocarbons in urban and polluted rural environments. *Atmospheric Environment* 33 (1999) 1821-1845

(a) Roadside sites



(b) Residential sites



**Figure 3** Ozone formation potential of VOCs groups at roadside and residential sites for different sampling periods

## Reviewer 2

Overall contents and methods were excellent to show the recent trends in VOCs study at the local scale. However, some parts need to be amended to increase the accessibility for reader.

In the methods of VOCs, a couple of related reference should be provided.

**Response:** Thank you for your comments. We have cited some references for our analytical methods.

Some explanations were doubly expressed, so shortened and condensed expression would be needed.

**Response:** We have revised our manuscript thoroughly condensed the expression in the text.

### Details

1.line 95: Experimental --> Methods ( I wonder the word of 'experimental" could be appropriate or not)

**Response:** We have revised it

2.line 96: block areas --> residential areas (residential would express the study site design well)

**Response:** Thank you for your comment. We have revised it thoroughly.

3.Experimental parts (2.1,~2.3.) did not mention or refer the related reference, related references will verify and intensify your methods. Please insert the related reference at proper sentence.

**Response:** Thank you for your comments. We have added some references to verify and relate to our analysis.

4.line 100: 7.am.-9am --> 0700~0900

**Response:** Thank you for your comment. We have revised it

5.line 184, table 1, --> Table 1a, upper low can be expressed with two lines : times /0700~0900, 1300~1500, please insert unit of concentrations ppb.

**Response:** Thank you for your comment. We have revised it.

6.line 263, table 1 --> Table 1b, upper low can be expressed with two lines : times /0700~0900, 1300~1500, please insert unit of concentrations ppb

**Response:** Thank you for your comment. We have revised it.

7.line 319, regional comparison is a good trial to know the status of taiwan, but it is not so reasonable to compare the city in different year due to different systems of traffics and fuel systems. I would suggest the deletion of table 2. Table 2 do not support your main story.

**Response:** Thank you for your comments. Table 2 is prepared to compare the ratios with other cities in the world. We have revised and condensed the Table 2 and made it to support the section.

### Reviewer 3

In the article, the authors determined the levels of outdoor air pollution (VOCs) caused by vehicle traffic for two areas: directly in the vicinity of the motorway and the residential area. Similar studies are carried out around the world to control air pollution in cities. The content shows that VOC measurements were carried out over 3 days during the summer (traffic peak and off-peak hours) in the urbanized part of southern Taiwan. The measurement methods are normative, but the boundary conditions are poorly defined. Due to the limited number of tests, in a limited time and place, a number of questions arise regarding the representativeness and usefulness of the presented results:

1. The limited number of tests (4 sampling places, 3 days) may affect the representativeness of the overall results. How the test/research schedule was built, what dictated the limited choice of 3 measurement days (14, 17 and 22 of July, 2014, holiday and summer)?

**Response:** We agreed three days sampling data was a limitation for this work; we have emphasized the issue in the text. The work is investigated 87 VOC species and 15 carbonyl species in the area that could be the advantages to explain the detail VOCs characteristics in traffic crowded downtown.

2. Why did the authors not address the weather data in the article: could the sun, wind (speed and direction), pressure and humidity influence the obtained VOCs concentration results?

**Response:** We agree the meteorological data are important factors to explain the variation of air quality. We have explained the weather parameter (shown as Figure 1). However the sampling sites were located in roadside and residential block, therefore the air pollution dispersion could be affected by the local turbulent fluctuations.

3. The measurement sites are not described in the article. This is important because the authors later show that the results may have been influenced by factors other than transport (human activities).

**Response:** Thank you for your comments. We have added a figure to explain the sampling sites and emission stationary sources (shown as Figure 1).

4. Why the authors have not decided to publish the results for 6 years. Do the results have any current useful sense, bearing in mind that current pollution levels in Taiwan are different today. The analysis of transport trends in Taiwan shows that the government has been investing in electric bus lines since 2017 and the market for electric vehicles (scooters) is one of the fastest growing in the world (16% of total Taiwan fleet are electric scooters).

**Response:** The electrical motor vehicles are rarely, most of vehicles are associated with fossil fuels (gasoline and diesel). Therefore, the engine combustion exhaust is the important sources of downtown in urban area. The data could be important to the air quality control strategy in metropolitan, especial for the motor vehicles control.

In Taiwan, some industrial facilities are located in the community; the situation could be different to other countries. The work could be a reference to avoid the industrial-community complex area in an urban area.

5. Authors should somehow justify their willingness to publish their results and state how the results contribute to the existing knowledge and how they relate to the interest of the Journal reader.

**Response:** We have revised the manuscript and point out the contribution to air quality management in an urban area.

6. The authors do not provide/assess the overall uncertainty for total VOCs (20 and 87 VOCs - tables 1a and 1b). Is it possible to provide it?

**Response:** Thank you for your comment. We have revised the tables.

7. The results of TVOCs (block site) are not correlated with the number of vehicles. The authors explain this by the influence of “other factors” that have not been specified/addressed in the boundary conditions.

**Response:** It is true the complex emission sources contributed to residential area. It is not easy to define the emission sources and some local emission sources were operations (laundry shop, motorcycles/vehicles repair shops, print shop etc), especial in the midnight.

8. The authors compared their results only with historical publications from 2001-2008. There are no more recent comparisons or at least the measurement period (2014)?

**Response:** Thank you for your comments. We have revised the Table 2.

Detailed comments:

1. Since the research is a typical case-study (in situ), it concerns “southern Taiwan”, I believe that it should be indicated in the title. The title “as it is” suggests a broader scope of the study.

**Response:** Thank you for your comments. We have revised the title.

2. The abstract focuses too much on the dry results obtained. I believe that this is unnecessary and the authors should rather say what is their intention in the work, what is the research hypothesis, the scope of the work and what is the result of the research for the Journal reader understanding.

**Response:** Thank you for your comments. We have revised the abstract.

3. In the introduction, the authors should say in my opinion why they conducted such research in the context of the current knowledge.

**Response:** We have revised the section of "Introduction".

4. Line 12, 92 and 97 repeat the same content.

**Response:** Thank you for your comment. We have revised these sentences.

5. A plan or map of the measurement sites and meteorological data (with an assessment of the impact on possible outcomes) would be useful.

**Response:** Thank you for your comment. We have made a map to explain the sampling sites and pollution (shown as Figure 1).

6. Line 101. Explain why the measurement days were representative. Were they accidental?

**Response:** We have point out the limitation of the shorter sampling days and the representation should be consideration. The detail VOC species was analyzed in air that is the main advantage for this study.

7. Line 114. When referring to a table (or tables), the table must be given directly after table reference (it cannot be in a different Section)

**Response:** Thank you for your comment. We have moved the Table after the referring of sentence.

8. Avoid using bold markings in the content (line 114)

**Response:** We have revised the bold markings in the manuscript thoroughly.

9. Line 121. TO-15 Method is quoted without reference to the literature. Need to be addressed.

**Response:** We have cited two references for the TO-15 methods.

10. Line 123. The measuring equipment should be referenced to the city and country.

**Response:** We have revised it.

11. Line 127. Does the relative standard deviation <10% refer to the measurement method or to the repetition of measurements in the same places on other days. NOTE: The measurement uncertainty of GC/MS for TVOCs is as per literature data 15-20%. Can you discuss?

**Response:** We presented the relative standard deviation less than 10% that was for the duplicated analysis of standard VOC species. Based on the Table 1 (VOCs concentration), high variations were determined for different sampling periods and days for both roadside and residential area. Therefore, the high accuracy was determined for our standard gas analysis, not for the samples.

12. The content should avoid using 'we' (line 169)

**Response:** Thank you for your comment. We have revised it.

13. Table 1 a and 1 B, the measurement uncertainty of VOCs (20 and 87) should be given, taking into account the measurement uncertainty and SDs of repeats in the same measurement places, because the results were averaged.

**Response:** We have explained the standard deviation for 87 VOCs (shown as Tables 1a and 1b).

14. Table 1 a, the results should be reported with the same accuracy (decimal places, see e.g. Toluene)

**Response:** Thank you for your comment. We have revised Table 1a and b.

15. Line 231-246, the content in my opinion does not match the Results

**Response:** We have revised the paragraph.

16. Figure 1. It should be stated in the caption whether it concerns 20 or 87 VOCs.

**Response:** Figure 1 is determined for 87 VOC species and 15 carbonyl species. We have revised the text and made it clear.

17. Figure 1. I do not understand how the results of the concentrations in the figures were obtained. The values in Figure 1 do not correspond with the value levels to the results in Tables 1a and 1b. For example, the sum of the VOCs in the figure for Road sites is greater than any of the sum maximums of VOCs in Table 1a. Can you explain...

**Response:** 87 VOCs and 15 carbonyl species

18. Table 1b. "At night -NRH", 5 compounds have concentrations 10 times higher than during peak hours? If it is not a gross error, are the authors able to judge what might be causing it?

**Response:** The local activities included the laundry shop, motorcycles and vehicles repaired could be the one of reasons to cause high VOCs concentration.

19. Line 277. The authors explain ten times higher pollution at night as industrial and service activity of this area? Does this activity only take place at night?

**Response:** According to the investigated the high human activities were observed in the residential area, especial after the midnight. We have explained it in the text.

20. Table 2. The obtained results were compared with those of Tsai et al. (2003). The table shows that a significant number of results are equal to or greater than the values obtained for Motorcycle exhaust VOCs concentrations. How do the authors explain it?

**Response:** We have revised the Table 2. Some other sources and atmospheric chemical reactions could lead high VOCs ratios compared with the motor vehicles emission.

21. The article is not formatted in accordance with the MDPI guidelines. For example, the Journal template was not used for literature/bibliography.

**Response:** We have revised the format style to follow the Journal guidelines, special in references.

22. Table 3. As the results of the correlation of TVOCs and the number of vehicles are poorly correlated for "block sites", please add the corresponding table for "the road sites".

**Response:** We have revised Table 3 and presented the correlation of roadside and residential sites.

23. Figure 4. Can the authors give the uncertainty range to the results in the figure 4?

**Response:** The uncertainty ranges added into the Figure 4 and then the figure is not easy to figure out the values of ratios that suggest to omitting the uncertainty.

24. Line 372. Indicate whether 20 or 87 VOCs are involved in TVOCs concentrations

**Response:** The VOCs concentrations were based on 87 VOCs. We have rewritten the sentence.

25. 377. The authors should not translate the obtained results by such simplified assumptions (human activities)

**Response:** Thank you for your comments. We have rewritten the section. However, we have investigated the higher human activities in the area (such as laundry, motorcycles and vehicles shops) at night to compare with that during the daytime.

26. The authors in Conclusions may say what are the highlights of provided research (rather than repeating the values of the results)

**Response:** Thank you for your comment. We are highlights the important findings in the section of Conclusions.