

## Response to referees' comments

### Response to comments by referee RC2

#### General comments

The manuscript "Measurement Report: Source apportionment and environmental impacts of VOCs in Lhasa, a highland city in China" by Ye et al., presents VOC and other species measured in the highland city of Lhasa, China and identifies the major emission sources through PMF analysis.

The paper is very well written and organized. The information and discussion provided is very valuable and backed up by sound experimental data. In my opinion the scientific community will greatly benefit from the publication of this study.

The manuscript only needs a minor revision before being ready.

Response: We appreciate your constructive comments. We used them to improve our manuscript.

I think it would be useful to have more background and context about the parameters used in equations 3, 4, and 5 and some additional discussion on the importance of such assessments (especially for the toxicity parameters).

Response: accepted. We added more information in the revised manuscript.

The authors mention the collection of canisters in addition to the online GC system. It seems that the bulk of the discussion was based on the online result and it's not clear how the grab samples were utilized.

Response: Negative-pressure instantaneous sampling of whole-air samples was performed at Lhasa in different locations, including tunnels, diesel vehicle emission-impacted roadsides, refueling stations, renovation sites, and incense burning locations during the observation period. Totally 36 canisters were collected. The samples were analyzed via GC-MS within 10 days. Here, we compare the measured source spectrum with the source apportionment results of PMF analysis (see Fig. 5).

#### Minor Comments

1. A long list of acronyms is introduced in the abstract without being spelled out first: O<sub>3</sub>, NO<sub>x</sub>, OH, PMF, NG/LPG, BC, TP.

Response: We checked and corrected in the revised paper.

2. Line 62: change LOH to L<sub>OH</sub>

Response: accepted.

3. Line 72. Is the Okamoto and Tanimoto study specific for Chinese mountain sites?

Response: Okamoto and Tanimoto study included Mt. Waliguan in the Tibet Plateau.

4. Sentence starting line 74: "Among these studies ..." needs references

Response: we added references of Liu et al., 2013; Ran et al., 2015; Cui et al., 2018.

5. Line 88. Indicate population of Lhasa

Response: added. In the 2020 census, Lhasa has a permanent population of about 870,000, with an increase of 55% compared to 2010.

6. Line 90. Please explain in different ways what you mean by "The city is not green or hot"

Response: Large areas of high mountains around Lhasa are bare, and vegetation coverage is less than 10% for sure. Coupled with low temperature throughout the year, plants are not flourishing, hence high biogenic emissions are therefore not notably considered.

7. Line 93 and further down in the introduction: is there any data on how elevated O<sub>3</sub> is in the region? The authors mention multiple times "aggravated ozone pollution" without giving an idea on what the concentrations are for the reader to evaluate.

Response: Compared to the levels three decades ago, enhanced photochemical production of O<sub>3</sub>, for example, with an average increase of 10 ppb O<sub>3</sub> in 2012 when comparing with the afternoon O<sub>3</sub> peak in 1998, and therefore aggravated O<sub>3</sub> pollution were recorded in 2012 (Ran et al., 2014). Aggravated O<sub>3</sub> pollution even lasts to the present day, with a slower increasing slope over the last few years (Yin et al., 2019). From 2005 to 2018, Lhasa had an average of 19 days with the maximum daily 8-h O<sub>3</sub> exceeding 100 µg/m<sup>3</sup> per year (Li et al., 2020).

Li, R., Zhao, Y., Zhou, W., Meng, Y., Zhang, Z., Fu, H.: Developing a novel hybrid model for the estimation of surface 8 h ozone (O<sub>3</sub>) across the remote Tibetan Plateau during 2005–2018. *Atmos. Chem. Phys.*, 20, 6159-6175. <https://doi.org/10.5194/acp-20-6159-2020>.

8. Canister Sampling – line 165. When were the cans collected? How many? Where? How long was the sampling time?

Response: Negative-pressure instantaneous sampling of whole-air samples was performed at Lhasa in different locations for typical emissions, including tunnels, diesel vehicle emission-impacted roadsides, refueling stations, renovation houses, and incense burning locations during the observation period. Totally 36 canisters were collected with three samples for each type of emission sources. The samples were analyzed via GC–MS within 10 days.