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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Urban stress-induced biogenic VOC emissions impact secondary aerosol formation in Beijing" *by* A. Ghirardo et al.

Anonymous Referee #3

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In this study, the impact of biogenic volatile organic compounds (BVOC) on secondary aerosol (SOA) formation in megacity Beijing has been investigated. In the Beijing, there was a large tree-planting program for the 2008 Olympic Games and the BVOC emissions from woody plants were estimated before and after the games in 2005 and 2010. The authors determined the abundance of different plant species in the urban area of Beijing and selected 22 woody plant species for detailed VOC emission analysis. Furthermore, four model plant species were exposed to elevated concentrations ozone to measure stress-induced BVOC emissions. The BVOC emissions were classified into two groups: constitutive and stress-induced BVOCs. Finally, the SOA formation potential of biogenic and anthropogenic VOC was estimated based on VOC emission budgets.

The results obtained indicate that annual BVOC budget may have doubled from 2005 to 2010 due to the tree-planting program. The stress-induced BVOCs were estimated to be contributed ca. 40 % to the formation of total biogenic SOA. In addition, an average concentration of biogenic SOA were estimated to be doubled from 2015 to 2010; however it still contributes only ca. 4 % of total SOA formation. Although, biogenic SOA contributes only a few per cent to total SOA, the selection of suitable low-emission plant species could have positive effects on urban air quality.

The study presents new and important results on the biogenic VOC emissions (including stress-induced emissions) and the SOA formation in the urban megacity Beijing. Although the study contains many assumptions and generalizations, the results can be used to estimate the importance of biogenic emissions in urban areas. The manuscript is quite well organized and written, and the scope of is suitable for publication in this journal. The methods and experiments have been well described and conducted as well as the results are well reported and analyzed. Overall, the manuscript is suitable for publication in this journal. However, there are some minor comments and suggestions that should be considered before publication.

General comments:

This study shows that a large scale tree-planting could lead to substantial increase in concentrations of particulate matter in urban areas which might have adverse health effects. Please discuss shortly toxicological/adverse health effect of biogenic SOA in the manuscript. Is biogenic SOA as "toxic" as anthropogenic SOA which often contains, e.g., PAH compounds.

Obviously, tree-planting have also positive effects. For instance, plants can also remove a considerable amount of particulate matter and harmful gaseous compounds from urban air (see, e.g., Beckett et al, 2000; Nowak et al. 2013). Please add more discussion on the positive effects of plants on urban air quality.

Table 1 shows results from woody plant inventory in the urban area of Beijing. The most

abundant species are evergreen trees, however, none of them were used in detailed analysis. Why do evergreen trees have been excluded? What could contribution of evergreen trees be on VOC emissions and SOA formation? Please clarify the role of evergreen trees.

VOC compounds have been classified "constitutive" and "stress-induced" classes. For instance, alpha-pinene has been classified as "constitutive" BVOC. To my knowledge, emissions of many "constitutive" monoterpenes can increase significantly after abiotic or biotic stress, especially for conifers. How has this been taken into account in model calculations? Has this any effect on final results and conclusions?

In the ozone fumigation test, VOC emissions were collected for 20 h after ozone exposure. Please clarify what are long term emissions of stressed plants? What will emissions be after several days/weeks? Please discuss long term effects on VOC emission and SOA formation (Does it have any effect on results and final conclusions?).

There are many assumptions and generalizations in model calculations. How realistic are the results? Please make a rough error analysis to get an estimate of the reliability of the results (e.g. 10 % or 50 %). In addition, compare the modeled results with measured ones in more detail (e.g., VOC and mass concentrations).

Please check language.

Specific comments/ technical corrections:

2 Materials and methods (page 23011): In this study, several separate experiments and studies have been combined together. At the beginning of this chapter (before Ch. 2.1), a short summary would help reader to understand easier the experiments and model calculations conducted in this study.

2.1 Plant material (page 23011): "Two fully developed leaves from three trees were independently measured for each species in the period from August to mid-October in 2011." Please define what has been measured.

Page 23011, line 14: lab => laboratory

Page 23012, line 13-14: "...set by the US-Environmental Protection Agency and the United Nations Economic Commission for Europe (UNECE)." Please add an appropriate reference.

2.3 Laboratory study of ozone-induced BVOC emissions (page 23012). Why do those model plant species have been selected? Are they representative? Please clarify in the text.

Page 23014, line 23: Please define acronym MSD if not commonly know.

Page 23016, line 15: "...a reference temperature (48 C)". The reference temperature of 48 C seems to be high, please clarify the background of this high reference temperature.

Page 23017, line 25-: "The height of the box was fixed to 2 km, as a typical proxy for the height of an inversion layer." Please give a suitable reference for 2 km inversion layer used in calculations.

Page 23018, line 25-: "... we assumed that the atmospheric lifetime of particles is approx. 4 days." Please give a suitable reference or clarify the use of 4 days particle lifetime.

Page 23020, line 20: "two well-known strong isoprene-emitters." Please give a suitable reference.

Page 23023, line 10: "1.05 μg in 2005 and 2.05 μg in 2010". Please check units (μg/m3?).

Page 23026, line 1-: "However, measuring sBVOCs such as SQT in ambient air is challenging due to their high reactivity with O3 and/or other reactive oxygen species (i.e., OH radicals), and sBVOCs might thus already be oxidized before being detected." Furthermore, SQT and other low-volatile compounds easily condense (or stick) onto

walls of sampling pipes and leaves of plants. Please clarify this point in the text. Is condensation onto sampling lines inhibited during experiments?

Page 23028, line 13-: "Mentel et al., 2013 measured" => Mentel et al. (2013) measured

Page 23028, line 27: "Odum Jay et al." => Odum et al. Please check also the reference (p. 23039, l. 13).

Table 1 (page 23042): Please add a reference for the plant coverage data base used in this study.

Table 2 (page 23043): Explanations of column abbreviations could be first before other in the caption text (easier to read).

Figure 1 (page 23044): What is reason for high value of GLVs? Please add error bars of emission rates (e.g. standard error/deviation). Abbr. "nd" not defined.

Figure 2 (page 23045): Abbr. PPFD not defined (panel A).

Figure 4 (page 23047): The upper panel (A) is not easy to read. Should only total emission rate be presented because relative concentration of different compounds are presented panel B.

Figure 6 (page 23049): Biogenic SOA and Anthropogenic SOA could be more informative texts in y-labels.

References:

Beckett, P.K., Freer-Smith, P.H., Taylor, G., 2000. Particulate pollution capture by urban trees: Effects of species and windspeed. Global Change Biology 6, 995-1003.

Nowak, D.J., Hirabayashi, S., Bodine, A., Hoehn, R., 2013. Modeled PM2.5 removal by trees in ten U.S. cities and associated health effects. Environmental Pollution 178, 395.

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