

## ***Interactive comment on “Three Northern Regions Shelter Forest contributed to long-term increasing trend of biogenic isoprene emissions in Northern China” by Xiaodong Zhang et al.***

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Responses to reviewer's comments: Dr. K. Sindelarova, Reviewer #1

General comments The paper touches an interesting topic of impact of human induced ecosystem changes on air quality. It studies trends of isoprene emission in Northern China with focus on artificially grown ecosystem of Three Northern Regions Shelter Forest (TNRSF). By using model of biogenic VOCs the paper shows that there is an increasing trend in biogenic isoprene emissions in the TNRSF region over the period of 1982 to 2010, which is likely to increase with further plantation of this human induced forest. Particularly, the study shows that promoted tree plantation in Central-North China region close to agglomerations of Beijing and Tianjin brings higher isoprene

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emissions to the vicinity of potentially strong NO<sub>x</sub> sources, which can have significant impact on local air quality (e.g. surface ozone).

The base of the study is in modeling of isoprene emissions with the MEGAN model (Guenther et al., 2012). Additionally, the authors perform an uncertainty analysis of model inputs using the Monte Carlo method. And furthermore, they carry out a model evaluation by converting the measurements of total VOCs (TVOC) at several stations inside the forest to emissions of isoprene. Although the applied methodology of estimation of isoprene emission fluxes from measured TVOC concentrations is rather approximative, it provides a qualitative evaluation of modeled isoprene emissions. The paper is comprehensibly structured, written in appropriate level of English. I recommend its publication in ACP after minor revisions. Please see my specific comments and technical corrections below.

Response: We are very grateful for Dr. Sindelarova's detailed advice and constructive comments on the manuscript which benefit to the significant improvements of this paper. We agree with all of the suggested revisions and comments from the reviewer. Following the comments from Dr. , Sindelarova (Reviewer #1), we have revised the manuscript and address all comments from Dr. , Sindelarova. Our detailed responses and revisions in accordance with Dr. Sindelarova's comments are presented below. . Specific comments 1] Since the manuscript does not show any results on the impact of BVOC emissions on the 'ozone formation', it should not be included among the Key words.

Response: 'ozone formation' was removed from the key words.

2] P2L10 : "... emit harmful gases into the air ... " – gases that trees emit are not harmful per se, but they indeed contribute to air pollution through atmospheric chemistry. Please rephrase this sentence.

Response: In the revised manuscript, we have rewritten text as "they also contribute to air pollution through atmospheric chemistry".

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3] In section 2.1 authors do not mention which meteorological fields they used to drive the MEGAN model.

Response: In addition to air temperature mentioned previously in our paper, we have added "solar radiation, wind speed, humidity," in the revised paper.

4] P11L7-L9 : Comparison of Northern China emissions with emissions calculated for regions in the US. This sentence is a bit vague. Authors should specify why they chose the US regions for comparison and be more precise, e.g. add numbers of total amounts.

Response: We thought that MEGAN model has been applied extensively in the US. The results from the MEGAN modeling in the US might be used as a reference to validate our modeling results in China. Nevertheless, the text on the comparison of isoprene emissions between the US and Northern China have been deleted in the revised paper.

5] It would be helpful for orientation in the Northern China geography, if the figures with maps of emissions and emission trends (Figs. 3-5, S4, S6a, S7) included indications of meridians and parallels of latitude in the model domain.

Response: Following the reviewer's suggestion, meridians and parallels of latitude have been presented in the revised Figs. 3-5, S4, S6a, and S7, respectively.

6] It is not quite clear what is shown in Fig. 5. The description in the main text (P14L1) is not clear and the figure caption is the same as in Fig. 4b.

Response: There was indeed an error in the description and caption of Fig. 5. Figure 5 shows summer gridded trends of isoprene emissions whereas Figure 4b shows the annual trends. In the revised paper we have replaced "annual biogenic isoprene emissions" by "summer biogenic isoprene emissions". The same change was made in Fig. 5 caption. We have also added new text, indicating that the summer emission fluxes 'show a similar annual pattern to the annual emissions (Fig. 4b) but are greater than

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the annual emissions, as shown by Fig. 5" in the revised paper.

7] P16L4: Authors compare their results of isoprene emissions in Central-North China regions with emission estimates by Li et al. (2013). They claim the results are comparable. However, the upper limit of their emission range is about 4 times lower than that of Li et al. (2013). Can authors comment on that, what could be the possible differences?

Response: We agree with the reviewer's comment. In the revised paper we acknowledged the difference of the upper limits of isoprene emissions between Li et al (2013) and our results and listed potential reasons causing this difference. Li et al (2013) adopted more locally updated species-specific emission factors and a vegetation classification based on a new vegetation investigation in the late 1990s and early 2000s in China. Their calculation used hourly and diurnal meteorological (temperature, radiation, winds) data. Our estimated fluxes were obtained using the emission factors specified in the MEGAN2.1 (Guenther et al., 2012) and vegetation types classified by the surface roughness lengths (Zhang et al., 2015). In addition, our model input daily meteorological data. These different input data to the MEGAN model likely resulted in the difference of the isoprene emission fluxes between Li et al (2013) and our result. These texts have been incorporated into the revised manuscript.

8] P22L2 – Discussion of the comparison of emissions in Northeast China and Inner Mongolia in 2010 and 1982 doesn't seem to be correct. While I agree with the authors conclusion that emissions are lower in 2010 than in 1982 (shown in Fig. 3) due to lower air temperatures (Fig. S7), the premises seem to be confused. The emissions in this region do not have a trend (as shown in Fig. 4b and Fig. 6), but the forest coverage increased between 1982 and 2010 (Fig. S6a). Assumption that the mixed forest reaches a steady state is unclear though. Can you be more specific?

Response: Reviewer raised a good question! We agree with the reviewer that, compared with the increasing trend of LAI in the Northeastern China region of the TNRSF

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(Fig. S6a), no statistically significant increasing trend of the isoprene emissions are discerned in this region. In addition to the LAIs, isoprene emissions also respond to light and temperature in terms of the MEGAN model. We further estimated the trends of gridded surface air temperatures (SATs, C) over the Northeastern China region of the TNRSF from 1982 to 2010. The result is presented in a new figure (Figure S7b, attached with this respond as Fig. 1) in the revised Supplementary. As shown, compared with the Central-North China region, the SATs in most places of the Northeastern China region exhibit a declining trend during this period of time. Since BVOC emissions are highly sensitive to changes in ambient temperatures (Guenther et al., 2012; Li et al., 2013), the lack of the incline trend of the isoprene emission fluxes in the Northeastern China region might be attributable to the decreasing SATs from 1982 to 2010. The above argument and point have been incorporated into the revised manuscript. In the revised manuscript, we have removed text on steady state of mixed forest in the Northeastern China region.

Technical corrections Main text: In the whole text please replace 'BVOCs emissions' by 'BVOC emissions', similarly 'VOCs emissions' by 'VOC emissions'

Response: Done! Thanks!

P2L17: replace 'anthropogenic emissions' by 'anthropogenic sources'

Response: Done!

P2L18: isoprene is a subgroup of terpenes (hemiterpene), please replace 'terpenes' by 'monoterpenes' or 'monoterpenes and sesquiterpenes'

Response: Following the reviewer's suggestion, 'terpenes' has been replaced by 'monoterpenes'.

P3L10: replace 'monoterpene' by 'monoterpenes'

Response: Following the reviewer's suggestion, 'monoterpene' has been replaced by 'monoterpenes' in the revised paper.

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P3L14: replace 'was from isoprene emission' by 'was isoprene'

Response: Done!

P4L10: replace 'tens percent' by 'tens of percent'

Response: Done!

P5L11: replace 'modeled increased dry deposition' by 'increased modeled dry deposition'

Response: Done!

P11L14: replace 'increased' by 'increase'

Response: Done!

P12L1 : reference to Fig.1 seems to be redundant

Response: Reference to Fig. 1 has been deleted.

P12L5: reference to Fig.3 seems to be redundant

Response: Reference to Fig. 3 has been deleted.

P13L1: I'd recommend to replace 'applicable model grids' by 'model grids that fall within the TNRSF domain' or similar

Response: Following the reviewer's comment, 'applicable model grids' has been replaced by 'model grids that fall within the TNRSF domain' in the revised manuscript.

P13L7: Fig.1 is not the right reference here since it does not show arid or semi-arid regions.

Response: Reference to Fig. 1 has been deleted.

P19L15: misspelled reference of Arneth et al.

Response: Corrected. Thanks!

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P19L17; replace 'tens percent' by 'tens of percent'

Response: Done! Thanks for the correction.

P21L7: Sentence starting 'However,...' does not make sense. Did the authors mean 'However, it is not yet clear ...' ?

Response: Reviewer is right! 'yet' is 'not yet'. We have corrected this typo error.

P22L4: Missing space in 'between1982'

Response: Thanks to the reviewer for the correction! The space between two words has been added.

P22L14: Reference to Fig. 4b is misleading here. Either remove it, or refer to Fig. 4b directly after 'Northeastern China' in the same sentence and refer to Fig. 4a after '2000'.

Response: Following the reviewer's suggestion, we have removed the reference to Fig. 4b in the revised paper.

References: - missing year of publication for Guenther et al., Estimates of regional natural volatile organic compound fluxes from enclosure and ambient measurements.

Response: Missing year and full authors list have been added in the revised reference.

Figure caption to Fig. 6 – please edit the text, only one dotted line is shown in the figure.

Response: Following the reviewer's comment we have edit the text and made corresponding changes in the figure caption of Fig. 6.

Supplementary material: - in section of Simplified Gaussian model for an area source – variable 'Cis' is not defined.

Response: Cis has been defined in the revised Supplementary material.

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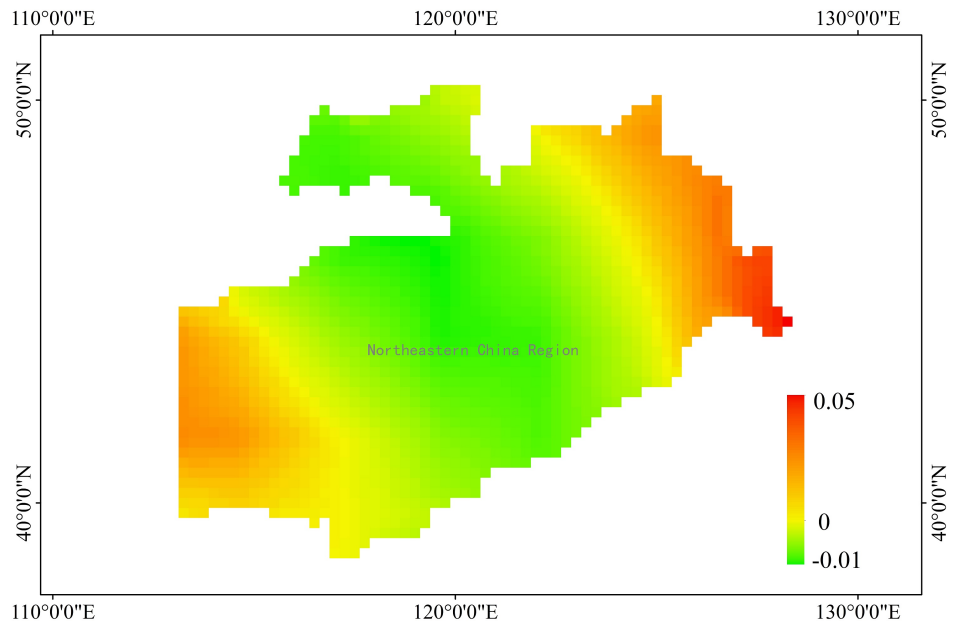
Figure caption to Fig. 6b – replace 'LAT' by 'LAI'

Response: Yes LAT is 'LAI'. This error has been corrected. Thanks!

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Interactive comment on Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2015-944, 2016.

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**Fig. 1.**