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Atmospheric Chemistry and Physics Discussions

# *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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Anonymous Reviewer #3

Long term trend of isoprene emission in the Three Northern Regions Shelter Forest (TNRSF) from 1982 to 2010 was evaluated, using a biogenic emission model for gases and aerosols (MEGAN). Isoprene emission flux has increased substantially in many places in the TNRSF due to the increase of trees and vegetation coverage, especially in the Central-North China region. The estimated isoprene emissions suggest that the TNRSF has altered the long-term emission trend in North China. I recommend its publication after addressing some questions. Please see the questions and comments bellow:



Response: We appreciate Anonymous Reviewer#3 for his or her comments and the constructive criticisms which help us to improve considerably our manuscript. Based on the comments from the Reviewer #3, we have made relevant revisions to the manuscript. Following are reviewer's comments and our responses.

Specific comments: P2L10: they also emit harmful gases into the air. By our understanding, these gases are not harmful, please correct it, or cite references here.

Response: We agree with the reviewer's comment! In the revised manuscript, we have rewritten text as "they also contribute to air pollution through atmospheric chemistry"

P6L12: MEGAN2.1 is primarily driven by biological and meteorological factors, including vegetation type with which the emission factors of BVOCs are assigned, air and leaf temperatures, light, leaf age and leaf area index (LAI), and soil moisture. Please introduce these data sources in the calculation for past three decades, the uncertainties of all these parameters used in the model for TNRSF, for example PAR, emission factor.

Response: Following the reviewer's comment, in the revised paper we have added text describing the data sources of meteorological data used in the modeling 30 years isoprene emissions, including a website and a new reference (Zhang et al., 2002). In the uncertainty analysis, we referred to Situ et al's work (2014) for the uncertainty analysis of the MEGAN model in which PAR and temperature were found to be most important environmental factors contributing to the uncertainties of the MEGAN model. We also further introduced PAR as one of the MEGAN model input parameters in our uncertainty analysis and rerun the Monte Carlo model. New results are presented in revised Fig. S1 and Table S2 of Supplementary materials.

P9L6: What are the sampling numbers at 8 sites in a field campaign? More introductions should be given for the measurements, such as VOC species and concentrations.

Response: The sampling frequency was set at 1 min. Since the GreyWolf VOC sensor

can only measure TVOC, the concentration of individual VOC species is not reported here. These have been mentioned in sections 2.4 and 3.4 in the previous and revised paper. Figure 8 illustrates sampled TVOC concentrations per minute.

P12L10: It's better to use mg m-2h-1 instead of micro-moles m-2 hr-1.

Response: Thanks for the suggestion! The use of this unit followed Guenther et al. (2012, see Reference list). We figured out that using this unit we could better compare and illustrate emission fluxes inside and outside the TNRSF. For instance, Figure 7 compares isoprene emission fluxes within the TNRSF, a natural forest in Northeastern China, and outside the TNRSF. Using micro-moles m-2 hr-1 the annual variation of the emission fluxes in these three regions can be nicely presented in the same panel of the figure. Whereas, the use of mg m-2 h-1 the annual fluxes outside the TNRSF cannot be shown in Fig. 7 because the fluxes become too small using this unit as compared with those within forests. Therefore, we prefer to use micro-moles m-2 hr-1.

P14L17 (and P22L14): These natural forests already reached the steady state, is there any evidence from botanical field?

Response: We don't have botanical data to show evidence of steady-state natural forest in Northeast China. Instead, we added two references which indicated that a natural forest could be assumed to be in a steady state. In the revised manuscript, we rewrote the text as " This implies that this natural forest was likely under a steady state from which the biogenic isoprene emissions were not altered on the decadal basis (Sanderson et al., 2003; Purves et al., 2004)".

P15L13: No direct measurements of BVOCs emission data across the TNRSF have been ever reported before. This sentence should be corrected. Some measurements of BVOC emissions and concentrations in TNRSF region had been carried out, for example: Klinger L.F., Li Q.J., Guenther A. et al. 2002. Assessment of volatile organic compound emissions from ecosystems of China, J. Geophy. Res., 107(D21). Wang Z.H., Bai Y.H., Zhang S.Y., 2003. A biogenic volatile organic compounds emission



inventory for Beijing. Atmospheric Environment. 37, 3771-3782. Bai J.H., Baker B., Liang B.S., Greenberg J., Guenther A., 2006. Isoprene and monoterpene emissions from an Inner Mongolia grassland. Atmospheric Environment. 40(30), 5753-5758. There should be more others that can be used for the evaluation.

Response: We thank the Reviewer#3 for letting us know these references. We did not cite some of these references because the field measurements reported in these references were not conducted in the TNRSF. e.g., Wang et al.'s field work was done in Beijing and Bai et al.'s study was focused on the grassland of Inner Mongolia. Nevertheless, following the reviewer's comment we have revised the text as "No extensive and direct measurements of BVOC emission across the TNRSF have been ever carried out. Several field campaigns have been conducted to measure BVOC emissions in Northern China but they were not typically designated for the TNRSF (Klinger et al., 2002; Wang et al., 2003)". These two references are also added to the Reference list.

P19L12: The increasing biogenic isoprene emissions can be attributed to the development of the TNRSF (i.e., LAI), how about the roles of other factors, PAR, temperature. My suggestion is to consider these parameters in all analysis, including P24L3. Where are figures Fig. S6a and b?

Response: We agree with Reviewer's comments! BVOC emissions do depend on other parameters and factors. We have shown that lower temperature in 2009 than 1982 in the Northeast China region of the TNRSF led to lower isoprene fluxes in 2009 in this region. In the revised manuscript, we have also added Fig. S7b which further shows decreasing trends of annually averaged temperature in the Northeast China region where LAI showed the incline (Fig. S6a) but BVOC emissions exhibited negative trends (Figs. 4 and 5). We suggested that declining temperatures in this region might cause the decreasing trend of isoprene emissions. Corresponding discussions have been incorporated in the Discussion section in the revised manuscript. We also wrote " Another environmental factor that may exert strong influence on the trend of isoprene emissions is solar radiation/PAR (Situ et al., 2014). Analogous to the response of

the BVOC emissions to temperature, increasing radiation could also enhance the isoprene emissions, or vice versa, particularly on daily or monthly basis." in the revised manuscript.

Fig. S6a and b are cited in Discussion section and presented in Supplementary materials.

P24L16: emission minus dry deposition? please make it clear.

Response: Thanks to the Reviewer to indicate this error. We have removed texts in the revised manuscript.

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