

Interactive comment on “How have both cultivation and warming influenced annual global isoprene and monoterpene emissions since the preindustrial era?” by K. Tanaka et al.

K. Tanaka et al.

ktanaka@jamstec.go.jp

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We are very grateful to Reviewer #1 for his/her time and questions/comments, which will make some aspects of this work more clear. We will appropriately address each of the points raised and have altered the text, figures and references to address the concerns as follows in the revised manuscript.

Response (R) to Comments (C):

General comments: C1: Abstract, 3rd line: Annual emissions are indeed illustrated in the Figures of the paper but emissions are not actually calculated at this time step (rather monthly), are they? Then please modify accordingly in ‘we simulated the annual

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emissions. . .

R1: We replaced “We simulated the annual emissions of volatile organic compounds (VOCs) during 1854 to 2000.” in P16516L4&5 with “We simulated the annual emissions, on a monthly basis, of volatile organic compounds (VOCs) during 1854 to 2000.”

C2: Abstract, last sentence, in ‘Overall, annual global isoprene emissions in 2000 werelower than in 1854, whereas annual global monoterpene emissions were higher’, could you specify by how much these emissions are lower?

R2: We replaced “Overall, annual global isoprene emissions in 2000 were lower than in 1854, whereas annual global monoterpene emissions were higher” with “Overall, annual global isoprene emissions in 2000 were lower than in 1854 by 13 TgCyr-1, whereas annual global monoterpene emissions were higher by 2.3 TgCyr-1.” Also, we determined that “564” TgCyr-1 for global annual isoprene emission in P16527L25 should be “560,” and so replaced “564” (i.e., the value in 1999) with “560.” Please note that these quantities include uncertainties in estimation.

C3: Section 2 Materials and Methods: could you explain what the ‘T85’ resolution is ?

R3: T85 is a 256 x 128 regular longitude/latitude global horizontal grid (approximately 1.4-degree resolution). The content is also shown in P16520L1. T85 indicates the truncation level in spectral space. We have also added “(256 x 128 regular longitude/latitude global horizontal grid; approximately 1.4-degree resolution)” after “T85” in P16519L13.

C4: Section 2 Materials and Methods: the description of how LAI and vegetation distribution are calculated and considered in this work could be clarified: how were the vegetation types from Ramankutty and Foley (1999) replace with those of MATSIRO, were they directly matching each other or were some combinations needed, for example ? For LAI, was a particular year chosen, or an average on several year, or was an interannual variability considered in the simulations ?

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R4: LAI was a monthly average over several years. We replaced “The level-4 Terra Moderate-Resolution Imaging Spectroradiometer (MODIS) global leaf area index (LAI) was applied to the monthly changes in LAI of both potential vegetation and cropland in each grid” in P16519L21-24 with “The level-4 Terra Moderate-Resolution Imaging Spectroradiometer (MODIS) global leaf area index (LAI), obtained from March 2000 to February 2009, was applied to the monthly changes in LAI of both potential vegetation and cropland in each grid.”

Regarding the conversion of vegetation types, we now describe the details in Sect 2.2:

We replaced “These were determined...by Ramankutty and Foley (1999)” in P16523L7-9 with the following text: “The C4 vegetation fraction during 1986–1995 and SAT (surface air temperature) during September 1957 - August 2002 were determined according to Takata et al. (2003), with reference also to Ramankutty and Foley (1999), as shown below. The C4 vegetation fraction and SAT data set were from the International Satellite Land Surface Climatology Project, Initiative II (ISLSCP II; daac.ornl.gov/ISLSCP_II/islscpii.shtml) and ECMWF (European Centre for Medium-Range Weather Forecasts) 40 Year Re-analysis (ERA-40) Data (Uppala et al., 2005), respectively. 1. Ice was converted from other areas, such as Antarctica and most parts of Greenland, where Ramankutty and Foley (1999) did not conduct classification; 2. BEF from Tropical Evergreen Forest/Woodland; 3. BDFW from Tropical Deciduous Forest/Woodland; 4. MCBDF from Temperate Broadleaf Evergreen Forest/Woodland, Temperate Needleleaf Evergreen Forest/Woodland, Temperate Deciduous Forest/Woodland, and Evergreen/Deciduous Mixed Forest (E/DMF) at the lowest monthly SAT of $\geq -3^{\circ}$; 5. CFW from Boreal Evergreen Forest/Woodland, and E/DMF at the lowest monthly SAT of $< -3^{\circ}$ and with ≥ 4 months at monthly SAT of $\geq 10^{\circ}$; 6. HLDFW from Boreal Deciduous Forest/Woodland, and E/DMF at the lowest monthly SAT of $< -3^{\circ}$ and with < 4 months at monthly SAT of $\geq 10^{\circ}$; 7. WC4G from Savanna and Dense Shrub (DS) with a C4 vegetation fraction of $> 20\%$; 8. SBG from Open Shrubland and Desert; 9. Tundra from Tundra and Polar Desert/Rock/Ice; 10. C3G

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from Grassland/Steppe, and Savanna and DS with a C4 vegetation fraction of $\leq 20\%$.”

We also added the following reference: Uppala, S. M., Kallberg, P. W., Simmons, A. J., Andrae, U., Bechtold, V. D., Fiorino, M., Gibson, J. K., Haseler, J., Hernandez, A., Kelly, G. A., Li, X., Onogi, K., Saarinen, S., Sokka, N., Allan, R. P., Andersson, E., Arpe, K., Balmaseda, M. A., Beljaars, A. C. M., Van De Berg, L., Bidlot, J., Bormann, N., Caires, S., Chevallier, F., Dethof, A., Dragosavac, M., Fisher, M., Fuentes, M., Hagemann, S., Holm, E., Hoskins, B. J., Isaksen, I., Janssen, P., Jenne, R., McNally, A. P., Mahfouf, J. F., Morcrette, J. J., Rayner, N. A., Saunders, R. W., Simon, P., Sterl, A., Trenberth, K. E., Untch, A., Vasiljevic, D., Viterbo, P., and Woollen, J.: The ERA-40 re-analysis, Q. J. R. Meteorol. Soc., 131, 2961-3012, 10.1256/qj.04.176, 2005.

C5: Section 2.1 with model description: To my opinion, this rather long description does not bring anything new since MEGAN is already described in the work by Guenther et al. (2006). I would therefore suggest to significantly shorten this section, focusing on the main differences and options selected in this work (for example no impact of past day or 10-days temperature, no direct impact of atmospheric concentrations on BVOC emissions) to highlight more clearly its specificities.

R5: 1. The original emission activity factor of light (Guenther et al., 2006) is different from that used here because a new parameter, LDF (light-dependence fraction) was included for the different light responses among isoprene and monoterpene emissions. The new factor is found in Sakulyanontvittaya et al. (2008), which is already cited. Therefore, we replaced the text in P16522L3 with “The emission activity factor of light is estimated after Sakulyanontvittaya et al. (2008), as follows:”. 2. There are few studies in which both isoprene and monoterpene emissions were estimated at the same time with MEGAN. Therefore, we feel that the differences in LDF, a fraction of foliage (F) and relative emission activity (A) among isoprene and monoterpene emissions, should be described here. 3. For readers, we have also described in detail how monthly input data, such as SAT, DSR and LAI were used in the MEGAN. Thus, we believe the model description is needed in Sect 2.1 and have decided not to change this.

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C6: Section 2.2, first sentence in 'Figure 1 shows the distribution of potential vegetation': is it the past, present or future potential vegetation ?

R6: Ramankutty and Foley (1999) stated that the natural vegetation in their data set was representative of the world's "potential" vegetation (i.e., vegetation that would most likely exist now in the absence of human activities). Therefore, we replaced "potential vegetation" in P16523L2 and in the figure caption with "current potential vegetation."

C7: Section 3.1, in the description of Figure 4: as boxes for the different A1 to A11 are not illustrated in the Figure, I would suggest to remind the location when mentioned in the text, to make the reading and understanding easier.

R7: We revised Figure 4c to include boxes indicating A1 - A11 and have replaced the current figure with the new figure. We also added "Targeted areas (A1 – A11) are shown in (c)." at the end of the caption.

C8: Section 3.1, description of Figure 5, and in the related caption : Please specify what the calculated '%' stand for: contribution of each vegetation type to the total emissions for the region considered ?

R8: It is the ratio of each vegetation area to the land surface area in A1 – A11. The values of land surface areas at 100% are shown in Figure 2. We replaced "Interannual changes in vegetation distribution during the period 1850–2005 in regions A1 through A11." in the caption with "Interannual changes in the ratio of vegetation area in regions A1 through A11 during the period from 1850–2005." We replaced the sentence in P16526L14&15 with "Figure 5 shows the increase in cultivation and changes in vegetation types in A1 through A11 during the period from 1850–2005 as the ratio of each vegetation area to each targeted land surface area."

C9: Section 3.2 and generally in the text: the authors refer most of the time to 'crop expansion'. However, as is illustrated in the Figure 5, some regions do experience for some years some decrease, rather than increase, in crop surface. I would therefore

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recommend to use the more appropriate expression of 'land-use change'.

R9: "land-use changes" may be better than "expansion of cropland." We already stated "the expansion of cropland (or land-use change)" in P16520L7&8, Sect. 2, and feel that "the expansion of cropland" is suitable in almost all cases.

Specific comments: C10: Abstract, 5th line before the end: replace 'emissions' by 'compounds' in '. . . was generally the lowest for both emissions'

R 10: We replaced "both emissions" in P16516L23 with "both compounds."

C11: Abstract, 5th line: Please specify here what 'SATs' stands for or write in full.

R11: We replaced "surface air temperature (SAT)" in P16516L2 with "surface air temperatures (SATs)."

C12: Introduction : replace 'Vegetation is though to emit about 90% of volatile organic compounds' by 'Vegetation is thought to contribute to about 90% of global emissions of volatile organic compounds'

R12: We replaced "Vegetation is thought to emit about 90% of volatile organic compounds" with "Vegetation is thought to contribute to about 90% of global emissions of volatile organic compounds."

C13: Section 2 Materials and Methods: the first sentence is about 7 lines which is a bit hard to follow, could be for example cut in 2 before 'reproduced'.

R13: We replaced this sentence with "To estimate emissions for isoprene and monoterpenes (classified by eight components: myrcene, sabinene, limonene, 3-carene, ocimene, β -pinene, α -pinene, and other monoterpenes), we used the MEGAN model (Guenther et al., 2006) and monthly climatic data including ambient solar radiation and air temperature at 2 m above the land surface (Watanabe et al., 2011). The climatic data were reproduced by a historical run from 1850 to 2005 with MIROC5 (Watanabe et al., 2010), which is an atmospheric ocean circulation model with the standard

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resolution of the T85 (256 x 128 regular longitude/latitude global horizontal grid; approximately 1.4-degree resolution) atmosphere and one-degree ocean models.”

C14: In the text and in the references: change ‘Serca’ to ‘Serça’.

R14: We replaced “Serca” with ”Serça” in both the text and references.

Tables and Figures: C15: Caption Figure 2: please modify ‘Targeted areas’ to ‘Targeted areas and related surface(in 107 km²)’.

R15: We replaced “Targeted areas” with “Targeted areas and related surface (in 107 km²).”

C16: Figure 4: please specify in the caption how the extent of cropland is illustrated: grid fraction?

R16: Yes, it is grid fraction. We have replaced “extent of cropland” in the caption and P16526L17 & L19 with “fraction of cropland.”

C17: Figure 5: please add the location of the region considered, for example as titles above the plots, to help the reading.

R17: “A1”, “A2”,...“A11” in Figure 5 has been replaced with “A1 (Europe),”, “A2 (Africa),”... “A11 (~21°S–90°S).”

C18: Figure 6: I suggest to stop the X-axis to the year 2000, at which the simulations performed here stop, and not 2010, which would also give the possibility to see better the graphs. Also to me the lines do not really appear to be dashed: please modify in the text, or change the drawing, and the ‘green’ line is rather blue.

R18: We revised this figure and Figure 8 with the same problem, and the range on the X-axis is now 1850 to 2000. We replaced these figures with new versions. We deleted “dashed” and “solid” in the caption. “green” has been replaced with “blue.” Also, we replaced “DSA” with “DSR” in the caption, as it is incorrect.

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C19: Figure 7 caption: please specify the unit used.

R19: The unit used in the original manuscript was $\text{mgC m}^{-2} \text{ month}^{-1}$. However, we have revised Figure 7 and replaced the units used with $\text{mgC m}^{-2} \text{ yr}^{-1}$. Additionally, we indicate the units used in the caption.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 16515, 2012.

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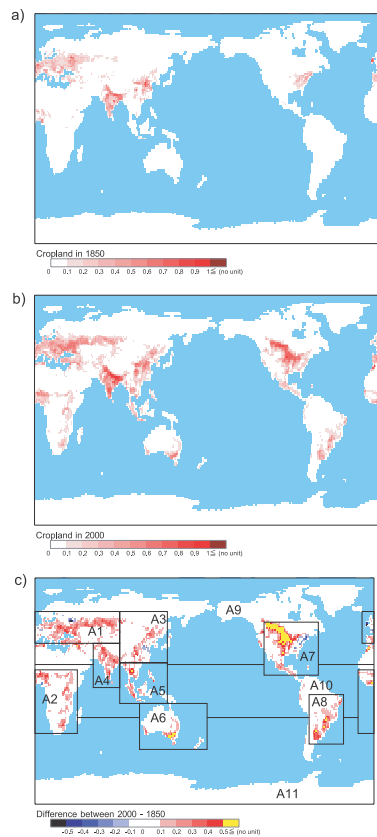


Fig. 4

Fig. 1.

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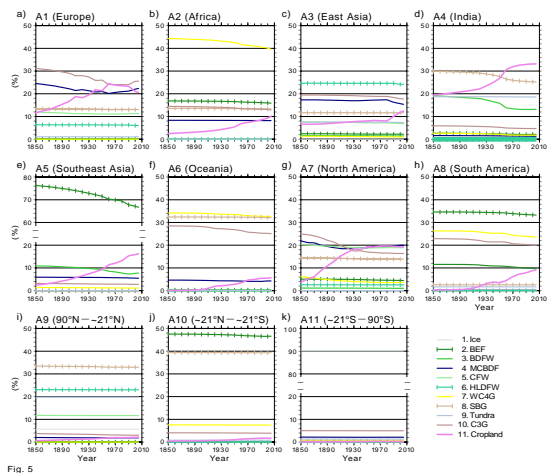
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Fig. 2.

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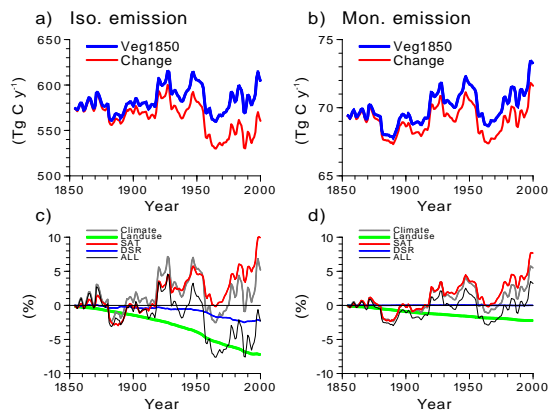


Fig. 6

Fig. 3.

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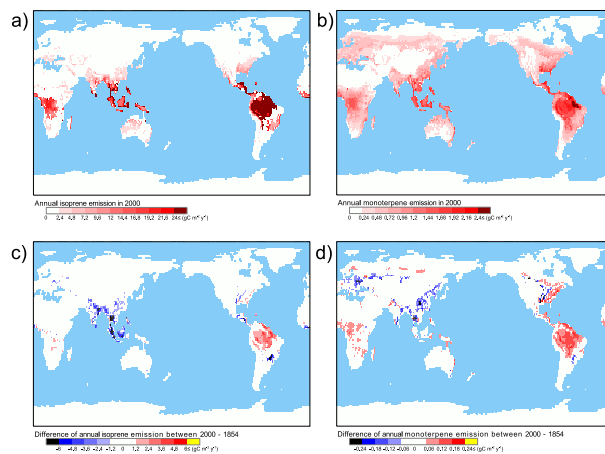


Fig. 7

Fig. 4.

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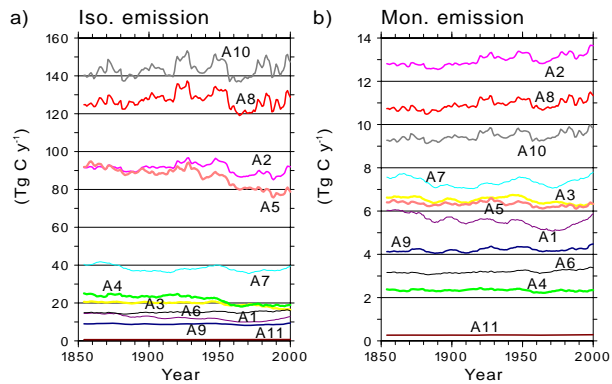


Fig. 8

Fig. 5.

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