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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Isoprene emissions over Asia 1979–2012: impact of climate and land use changes" *by* T. Stavrakou et al.

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We would like to thank the reviewer for his/her positive evaluation of the manuscript and for the useful comments and suggestions. Below we address the raised concerns. The reviewer's comments are *italicized*.

The paper presents an interesting evaluation of evolution of isoprene emissions in the last three decades over Asia using modeling driven by local land-use changes, climatology, in combination with top-down constraints from remote sensing and explicit consideration of recent field measurements at oil palm plantation and rainforest in Borneo. As field data of isoprene fluxes are extremely limited in Asia, satellite approaches seem to provide a robust approximation of the emissions.The top-down and bottom-up

estimates seem to agree well overall and over specific subdomains including China, India, Borneo, Japan, etc. This paper can clearly be an important contribution attracting attention to Asia in terms of air quality and land-use effects, and gives the motivation for focusing more atmospheric measurements in that region.

Questions/comments:

1. *Page 29554, Lines 7-11: "Moreover, Southeast Asia faced massive land use changes during the last decades, in particular deforestation and conversion of primary forests to croplands, leading to a decrease of isoprene fluxes, since crops are known to be weaker isoprene emitters than the forests they substitute".*

   Was the major expanding crop in Southeast Asia the oil palm? What fraction of croplands constitute oil palm plantations in Malaysia and Indonesia? As oil palm has an extremely high isoprene emission potential (e.g. Fowler et al., 2011), the statement could be true, if oil palm was excluded from the crops, but it is not clear in the text if this exclusion was made.

   Indeed the oil palm plantation is the most important expanding crop in Indonesia and Malaysia. In Indonesia (Sumatra, Kalimantan, and Papua) oil palm plantation area has almost doubled between 2000 and 2010. In the same period, intensive agriculture has increased by 46%, whereas the area of agroforest and other plantations has decreased by about 9%. In 2010 oil palms contributed 23% to the total cropland area, and accounted for approximately 5% of the total surface of Indonesia, as described in the study by Gunarso et al. (2013) based on LandSat satellite data.

   Oil palm plantation area has increased in Malaysia by 51% in 2000-2010, whereas agroforest and other plantations decreased by 15% and intensive agriculture remained almost constant. About half of the Malaysian cropland area was covered by oil palms in 2010. The oil palm area in 2010 accounted for 15% of the total area (Gunarso et al. 2013).

For clarity the text now reads : “Moreover, Southeast Asia faced massive land use changes during the last decades, in particular deforestation and conversion of primary forests to croplands, leading often to a decrease of isoprene fluxes, since crops are generally known to be weaker isoprene emitters than the forests they substitute (Guenther et al. 2006)."

The article Fowler et al. (2011) is now cited in the introduction.

Oil palms are excluded from the crops (see also next comment).

Gunarso, P., M. E. Hartoyo, F. Agus, and T. J. Killeen, Oil palm and land use change in Indonesia, Malaysia and Papua New Guinea, Reports from the Technical Panels of the 2nd Greenhouse Gas Working Group of the Roundtable on Sustainable Palm Oil (RSPO), www.rspo.org, November 2013.

2. *P29560 L.5 Treating oil palm as a separate PFT makes sense because it is a very specific crop type with orders of magnitude higher emissions capacities than most other crops. Was the expansion in oil palm area reflected in this PFT as the expansion in crop areas or how were crop and oil palm PFTs separated and used in the model?*

   The separation of oil palm from crop was made by simply subtracting the oil palm fractional area from the total crop area obtained from Ramankutty and Foley (1999).

3. *P29556 L21 Does the emission factor represent here the net flux above the canopy? If so consider adding this information.*

   Yes. In Section 2.1 the sentence now reads “More specifically, the net flux rate above the canopy is given by ...".

4. *P29568 L21 “HCHO columns and their error characterization are available at the TEMIS website (http://h2co.aeronomie.be)". I could not find any information on the error characterization at this link. It might be helpful to a reader to briefly describe the uncertainties here and if they are the same/different for the regions studied.*

   The reviewer is correct. Indeed, this information is not available on the website itself but it is included in the data files. For clarity we have added the sentence “A detailed error characterization of the columns is given in De Smedt et al. (2012)."

5. *P29552. L21 “The impact of oil palm expansion in Indonesia and Malaysia is to enhance the trends over that region, e.g. from 1.17% to 1.5% in 1979-2005 in Malaysia". By comparing S2 and S3 for Malaysia (Table 2 and Fig. 9) it seems that this enhancement is very small. In fact the emissions seem very slightly lower in S3 than S2. Is it because the model is so insensitive to the oil palm expansion vs more extensive rainforest, or is there perhaps an issue with the crop/oil-palm PFT or crop/oil-palm emission factor? See also next comment.*

   Emissions from oil palms in Indonesia were not considered in the MEGAN distribution of emission factors, and therefore, accounting for these emissions in S3 leads to a net emission increase in Indonesia. In Malaysia, however, MEGAN already accounted for the presence of oil palm. This is now clarified in Section 2.2 “Description of the simulations" with the following text:

   “Note that, over Malaysia, the S0 simulation already accounts for the presence of oil palm, as reflected by increased basal emission rates (3-4 mg m^{-2} h^{-1}) for the cropland PFT over this country. In S3, the basal emission rate of croplands (excluding oil palm) over Malaysia was set to 0.8 mg m^{-2}h^{-1}, comparable to values found over Indonesia in MEGAN. "

   The emissions are slightly lower in S3 than in S2, because the very high emission rates in the new oil palm PFT are more than compensated by the lower emission rate in the “other cropland" PFT. This is now mentioned in the fourth paragraph of Section 4 “Isoprene fluxes across S0-S4 simulations".

6. *P29564 L28: “While Indonesian emissions are increased, no significant change is found for Malaysia, where oil palm plantations were already considered as a major crop in the MEGAN distribution of emission factors." The MEGAN paper (Guenther et al., 2006, P.3189) assigns different emission factor to crops where oil palm is dominant and different emission factor to the remaining crop areas, so I assume the former emission factor or the emission factor from Misztal et al., 2011 was applied to the Malaysian region. If so, it is still somewhat surprising that S3 did not increase significantly the emissions between 1979 and 2005 (Fig. 9), for example as implied by the trends in Fig. 2.*

   The Misztal et al.(2011) algorithm has been applied in all oil palm plantations, not just in Malaysia. The relatively small change in the trend between S2 and S3 is simply due to the the fact that oil palms represent still a minor fraction of the total vegetated area over Malaysia.

7. *Some changes in the landcover-driving variables are attributed to a likely cause of significant changes in isoprene emissions (e.g., effects from the dimming due to aerosol or brightening due to reduction in clouds). This is very interesting over China where upward trend was observed in the base simulation and was further enhanced in S4 possibly by solar brightening in the isoprene-rich part of China. Could these changes in isoprene emissions result in a feedback on aerosol formation from isoprene oxidation and possibly induce the changes in the opposite direction?*

   This is an interesting remark. The feedback of isoprene emissions on aerosol abundances and properties are however still poorly understood and quantified.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 29551, 2013.