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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Probabilistic estimation of future emissions of isoprene and surface oxidant chemistry associated with land use change in response to growing food needs" *by* C. J. Hardacre et al.

L. Ganzeveld (Referee)

laurens.ganzeveld@wur.nl

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Review of paper acp-2012-865: Probabilistic estimation of future emissions of isoprene and surface oxidant chemistry associated with land use change in response to growing food needs by Hardacre et al.

The paper presents a study that focuses on the role of land cover and land use changes associated with scenarios on future biofuel production in BVOC emissions and the impact on surface ozone. The study is set-up around the development of a number of

LUC scenarios that consider the production of biofuels using the PLUM model system that actually does not provide only particular result but the results of an ensemble set of simulations to arrive at a bandwidth of plausible results dependent on the assumptions. These results on the LUC scenarios are then used to feed the GEOS-CHEM model to assess the impact of these LUC changes on isoprene emissions, soil NOx and ozone deposition. The results indicate that global scale impacts are very small, partly consistent with earlier studies, but that there appear to be regions for which substantial changes in LUC are anticipated where we also see significant changes in emissions, mixing ratios and deposition. The paper is well written describing well the analysis that has been done. On one hand I really appreciate the described activity on how to arrive at these more detailed approaches to arrive at global LUC scenarios and potential implications for atmospheric chemistry. I know from my own experiences that this is actually an extremely challenging task and which is generally underestimated by many of the large-scale atmospheric chemistry modelers who now start to consider the role of LUC in AC. On the other hand, I do question if ACP is the most optimal journal to indeed present this study with the detailed description of the LUC scenario activity. There are also some essential aspects that, according to me, miss in the presented analysis that would address the relevance of LUC in AC in a more balanced way. How do the differences in exchange and AC induced by LUC and biofuels compare to associated changes in anthropogenic emissions due to increases activity in these regions where biofuel production is increasing? I also find that the discussion of the impacts on the different regions is very extensive and would recommend to actually short this discussion and highlight the main contrasts between contrasting regions. What are according to your study the key interactions and regions that deserve most focus in follow-up studies?

Below you can find a list of more minor comments to be addressed in a revised version of the ms.

Line 179; can you shortly explain the difference between first- and second generation biofuels?

Having read through section 2.2, that describes in a lot of detail all the steps/assumptions made to arrive at LUC associated with biofuel production I wonder about the role of some of those very basic assumptions (that must be made) relative to the added value of conducting 1000 simulations with this PLUM system. Do you actually need to do that many simulations to actually cope with some of the very crude assumptions or would it be more appropriate to explore only the extremes based on the most essential assumptions?

Section 2.3; also here quite some steps are needed to link the country-based LUC information to the plant functional types being considered in MEGAN and to arrive at a global distribution of crop land. It would be interesting to see how this global distribution in crop land ultimately compares to other existing crop land maps.

Line 235; "....that the isoprene emission factors assigned to a particular grid cell would not change". I don't get this. What do you mean. You are not changing the isoprene emission factor despite the fact that you get a change in the crop land fraction and contribution by natural and managed ecosystems?

Line 243: "We assumed that the soil NOx emission rates for additional food and biofuel were the same as the application rates for the existing crops described by Yienger and Levy (1995). We have used specific NOx emission rates where they have been reported, e.g., oil palm cultivation (Hewitt et al., 2009). We modified the soil NOx emissions within the standard version of GEOS-Chem (Yienger and Levy, 1995) to account for NOx emissions from fertiliser application and processing of the oil palm fruit to biodiesel.". This addresses a tricky part of such studies on the impact of LUC on biogenic emissions, dry deposition and other processes. How is in the current implementation of the soil NOx emissions the fertilizer being considered. Those fields might be from a different data source that gives fertilizer application where according to your global crop land map there is no agricultural activity or vice versa. Did you ever

overlay the fertilizer/soil NO emission factor map with your cropland map to detect such potential inconsistencies. The way that soil NOx has been considered is especially essential for the more remote regions with not that large anthropogenic (industrial and energy production) sources of NOx determining the impact of BVOC emission changes on oxidant levels and chemistry.

Line 269: "For example if the rate of increase in crop yield was lower than the increase in global cropland area and corresponding decrease in forest and grass land area was greater, i.e. more cropland was required for food production when crop yields were lower (and vice versa).

Line 275: "In 2015 global cropland area changed between -13%– +47%, with the median realization resulting in a small decrease of -3%." Changed compared to what, relative to 1990?

Lines 300-305; here you suggest that you are discussing the actual LUC changes that occurred, also by stating for example that "no data were available for the Democratic Republic of the Congo". But these are all describing the PLUM model results. Why don't you have any simulation results for some countries and you should rephrase this text making clear that these are model simulated temporal trends in LUC.

In the section on the LUC impacts on isoprene emission fluxes I think it is relevant to mention here that changes in the global isoprene emission fluxes are negligible also recognizing that the uncertainties in the global isoprene emission flux of $\sim$500 Tg isoprene yr-1 would be on the order of a couple of 100 Tg's comparing the different existing global emission inventories. However, local differences in isoprene emission fluxes might be significant.

Reading through section 3.3 I wonder to what extent also anticipated changes in anthropogenic emissions have been considered in your simulations. Where there will increased crop land use it is because there is a local/regional increase in population and activity. Changes in NOx that might ultimately determine the changes in oxidation chemistry will mostly be dominated by changes in anthropogenic NOx emissions. But it also depends critically on your assumptions on how much fertilizers have to be applied to support the growth of all those biofuels (see previous comment)

Line 434: "Figs. 8b and d show that the conversion of forest and grassland to cropland generally resulted in decreases in surface NOx mixing ratios and increases in the O3 surface flux (i.e. reduced dry deposition to the biosphere) in Brazil"; so you simulate a reduced O3 dry deposition flux that is reflected by an increase in the O3 surface flux. I read your definition on the sign of the flux but now get confused again also since the decrease in isoprene would result in an increase in O3 that compensates for the decrease in the removal rate (dry deposition velocity) due to the decrease in LAI and roughness. Why not simply put here "..decreases in surface NOx mixing ratios and O3 dry deposition flux in Brazil?

Line 441: "-10– -12.5 ppb"; this indicates that the model simulates isoprene mixing ratios > ~15 ppbv over tropical rainforest. We know that this is (still) a common feature of global models that use the state-of the art emission algorithms but where this problem is now often tackled by changes in isoprene chemistry that result in simulations of more realistic OH concentrations and also reduce the simulated isoprene mixing ratios. This should somehow be discussed in the paper.

Line 444: "Ganzeveld et al. (2010) also reported reductions in forest cover and increased cultivation intensity in Brazil, which resulted in reduced isoprene fluxes and increased soil NOx emissions (surface mixing ratios were not reported)." In that study we found that despite a decrease in soil NO emissions (also due to a significantly smaller NO emission factor for cropland) that atmosphere-biosphere NOx fluxes (explicitly simulated with a multi-layer canopy model) were not that much affected since changes in the in-canopy chemistry and deposition resulted in a more efficient release of the NOx from the canopy. I mention this since such subtle features of the exchange are of relevance for the impact of these changes in isoprene, NOx and (O3) dry deposition and that also urge for the use of more explicit representations of these canopy

interactions.

Reading through the discussions on the impacts of LUC in the different regions; I do see the point that there are differences between the regions but at some point some of the discussed responses are quite obvious and become repetition. I feel that the description of the results would profit from shortening it and focus on some contrasting results between the contrasting regions.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 33359, 2012.