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Interactive comment on "Impact of climate variability and land use changes on global biogenic volatile organic compound emissions" *by* J. Lathière et al.

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We thank sincerely Mr Thomas Karl for reading our paper and giving his opinion and suggestions to improve it, as well providing a useful bibliography. We made an effort to integrate his remarks in our manuscript.

General comments:

1-Given the focus on climate and landuse change, the authors might not be aware of recent findings on biogenic emissions. For example, Rosenstiel et al. (2003) observed decrease isoprene emission under elevated CO2 due to biogeochemical changes. It is clear that at this point it might be difficult to include these observations in global veg-

etation models. Nevertheless, these findings are important to at least be considered in the discussion as they could have ramifications on modeling future isoprene emissions. We completely agree that the recent finding by Rosenstiel et al. (2003) could be a key parameter in biogenic emissions study and estimates on long time-scales. Nevertheless, we consider that the effect over the 1983-1995 period we are interested in, for which the atmospheric CO2 increase reaches 5%, should be moderate. This point has also been mentioned by the two referees and convenient modifications have been made in the text. We thus included a discussion on this subject in the conclusion, underlying the importance to consider this recent finding on long time-scales, such as the analyze of past or future emissions. "Rosenstiel et al. (2003) showed that under increased atmospheric CO2 level from 430 ppmv to 800 and 1200 ppmv, the isoprene production was reduced by 21% and 41% while above-ground biomass accumulation was enhanced by 60% and 82%. We can reasonably consider that considering this influence in our study would not change significantly the estimates calculated over the 1983-1995 period, characterized by a 5% increase of the atmospheric CO2 but could however be subsequent on longer time-scales."

2-Oxygenated VOCs: Emissions of these compounds are probably the least understood. A lot has been learned in the past 5 years. Example 1: It is not clear why the authors estimate that methanol emissions froms crops should be greater than in other ecosystems. The author cite one experimental publication obtained above a ponderosa plantation (Schade et al., JGR, 2000). Methanol fluxes reported in this publication are on average 1-1.5 mgC/m^2/h. The same authors (Schade et al., 2004) report methanol fluxes from agricultural landscapes of 0.1-0.2 mgC/m^2/h, which would be much lower. On the other hand, harvesting and natural drying of grass and crops resulted in increased methanol and other VOC emissions (Karl et al., 2001; Warneke et al., 2002), while recent laboratory screening of various crops showed considerable variability of oVOC emissions (Karl et al., 2005). It is not clear how changes of oVOC emissions are calculated based on the citations given in the present manuscript. For example, Guenther et al. (2000) gives generic biogenic oVOC emissions which are not speciated

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according to land cover. The cited publication by Fall et al. (1993) is exclusively based on laboratory leaf process studies. Direct up-scaling from these leaf level emissions is not possible. Example 2: Villanueva-Fierro et al. (2004) report ambient concentration of many oVOCs. Diurnal concentration measurements observed by these authors however do not necessarily have to be driven primarily by biogenic emissions. For example Rottenberg et al. observed diurnal acetaldehyde concentrations in the Amazon associated with uptake due to a compensation point driven exchange. Similarly carboxylic acids follow a compensation point driven uptake. Condensation in the branch enclosure system which is particularly problematic when sampling polar compounds might have masked the real nature of oVOC exchange reported by Villanueva-Fierro (2004). Kreuwieser et al. 2004) have observed significant increase of acetaldehyde emissions above flooded ecosystems due to ethanol transport from roots which is converted to acetaldehyde in the leaves through ADH. If isoprene biogenic emissions are now better understood, thanks to a lot of experimental studies, other VOCs still keep highly unknown, and we certainly have a lot to learn before our models give a perfect representation of the diversity and variability of those OVOC biogenic emissions. Nevertheless, several experimental publications such as the ones cited (Shade and Goldstein, JGR, 2001; Villanueva-Fierro et al., 2004) underlined that vegetation is also a significant source of reactive compounds such as alcohols, ketones or aldehydes, showing the interest to consider OVOCs in atmospheric chemistry studies, and not only isoprene and monoterpenes, and thus to integrate them in biogenic emissions model, which was not done up to day. We are fully aware that our biogenic emissions scheme will have to evolve in the future to integrate the knowledge and observations, both considering the parameterizations used and the emission factors prescribed. Considering methanol, very few studies compare the emission rate between natural and agricultural vegetation types. Nevertheless, such available studies or review (Mac Donald and Fall 1993, Kesselmeier and Staudt 1999) do suggest that methanol emission capacity is higher for crops compared to natural vegetation. The emission factors allocation in our model will of course have to be regularly revised and updated, based on new published

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information. For other detailed VOCs (acetone, aldehydes and acids), we took emissions factors from Kesseilmeier and Staudt (1999) and Janson and DeServes (2001) and tried to link as precisely as possible the available vegetal species to the PFTs of ORCHIDEE, completing the missing emissions factors hypothesizing that the emissions factors ratios calculated for monoterpenes could be used to deduce the missing other VOC emissions factors. We are completely conscious that this hypothesis is not based on any experimental results, since very few studies describing the level and the shape of biogenic emissions for compounds other than isoprene and monoterpenes are published. However, it must be pointed out that the main goal was to get VOC inventories comparing well with the few available global estimates thus to study their sensitivity to climate and vegetation changes and to use the few existing emissions factors to get a first idea of the estimates thus obtained. Instead of prescribing only one emission factor for every PFTs when no more information was available, as it is done for OVOC emissions calculation, we made the choice to simulate a PFT-to-PFT variability by using the monoterpenes emission factors ratio. Emission factors will of course be updated based on available information.

3-There are many more experimental field measurements published in the last 5 years that iterate on biogenic oxygenated VOC emissions. A better idea on landscape and leaf age variability of oVOC emissions might be gained from a more detailed literature review of recent field and laboratory studies. In particular comparison of flux measurements above different ecosystems and during different seasons might be valuable and show the variability of oVOC emissions under realistic scenarios. They could also provide guidance on how to improve parameterization and incorporation of oVOC emissions in large scale models in the future. On-site measurements and laboratory studies are of course highly critical for modeling field, enabling to build realistic parameterizations as well as to ensure that our models give a suitable representation of reality. We included in our paper comparisons between the results of our model and on-site measurements, illustrated in Table 4 and Figure 3, showing that the calculated emissions fluxes for several biogenic compounds are within the range of fluxes measurements. A

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more complete validation, for example by running the model “on-site”, considering the environmental conditions observed on the site of measurements, would of course help to evaluate more precisely our model. Nevertheless, this is a considerable work much beyond the scope of our study. It is indeed especially difficult to give a fair representation of natural emissions such as biogenic VOC emissions, characterized by a large spatial and temporal variability, at the global scale, and to integrate the whole diversity of compounds emitted and emissions level. The prescription of emission factor based on plant functional types, for example, is certainly a limited point that doesn’t allow to integrate the variability of the emission capacity of one plant functional from one region to another. A lot of work has still to be done.

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 10613, 2005.