

General comments:

(Initial paragraph or section evaluating the overall quality of the discussion paper)

This paper describes the updates in the BVOC emission module in the ORCHIDEE model. It further compares the predicted emissions by ORCHIDEE with the emissions predicted by the widely used emission model MEGAN. The paper also provides sensitivity test results to various parameters. The authors find that the spacial patterns of various BVOCs depend mostly on the allocated emission factor, while the seasonal patterns depend mostly on the leaf area index. The scope of the paper fits the journal well. The topic is timely, since there is a continuous need to inter-compare models and a strong need to test their sensitivity towards input parameters, though there is also a strong need to evaluate models against measurements. These needs arise as there are great variations in individual plant species and that these species that have very different potential to emit VOCs (both in amounts and in the distribution of individual VOCs) are only covered by a few emission potentials in global models - as is also emphasised by the authors. The authors also highlight that there are very many factors (both physical, but especially biological) that affect the emissions, hence one has to be cautious when making conclusions based on global emission estimates. Unfortunately, the paper is quite messy and there are many mistakes – both in the grammar, but more importantly in the use of symbols. This naturally has to be corrected. My main concern is how the emission potentials (EF) are allocated to the plant functional types (see also below). The handling of the EF is more detailed in the new emission module of ORCHIDEE (include higher degree of light dependency), but the justification of EF to different PFT has not improved and is also not properly justified. As the authors also specify, the impact of EF is dominant on the predicted emission and I therefore do not understand why the authors did not try to improve this part.

Specific comments:

(Section addressing individual scientific questions/issues)

- *) P33970L6-9: you could potentially supplement with some references.
- *) P33970L14: maybe you could also mention some of the papers that first showed the contribution of BVOCs to SOA formation and growth.
- *) P33970L9-18: Maybe you could also mention the contribution to CCN and clouds and hence climate.
- *) P33971L15-18: Maybe you could add some references?
- *) P33972L1-6: Also mention that phenology is not included in these models (e.g. MEGAN and ORCHIDEE), which is a big lack in order to describe the emission of VOCs.
- *) P33972L16-17: I agree, but maybe it is also worth mentioning that the temperature and light dependency not only depends on the VOC of interest, but also the plant species considered (e.g. Ghirardo et al., 2010) due to the different production paths.
- *) You discuss the sensitivity of the models with respect to LAI and also mention the discrepancy between modelled and measured LAI, but there is no word on biomass. I did a quick test with MEGAN and the emission scales proportionally with the biomass and non-linearly with LAI, and the emission is much more sensitive to the biomass than to the LAI. The effect of biomass has to be discussed in the paper. It would also improve the manuscript if there was at least some discussion on other canopy characteristics (canopy height, depth, age, ...).
- *) P33973L23-29: I do not agree with the authors at all! You cannot assess the correctness of a model by inter-comparing it with another model. This will only tell you how the models differ. As the authors mention earlier in the intro, more and more field measurements are done and it must be those that the models have to be evaluated against in order to evaluate their uncertainty. Unfortunately this has not been done enough, but there is a strong need to do so! A few examples are Tsigaridis et al., 2014, Mann et al., 2014 and Spracklen & Righelato 2014.
- *) It would improve the paper significantly if you included a section that clearly describes what is

the difference between your emission module and the MEGAN module. To me it seems that the largest difference is the land cover, which is anyway not predicted by your emission module, but LPJ (or LUH – not clear which). Otherwise it seems to me that you just changed the light dependency and emission factors and this you might as well just have been done in MEGAN.

*) P33976L1-2: I guess that this is also the case in MEGAN?

*) P33976L17-19: I guess the real argument is also that these are the compounds that have been measured to be emitted from vegetation in the greatest abundance?

*) P33976L25-26: Have you somehow taken the landcover of various species within a PFT into consideration when doing the averaging? If not, I am sceptical.

*) P33977L3-6: Please also mention the large change in boreal broadleaved deciduous trees, which I somehow doubt.

*) P33977L13-15: But one could look into e.g. forest inventories or similar in order to get a better idea.

*) P33977L25-29: Please also mention that the light dependency of a compound also depends on which plant it is emitted from (e.g. Ghirardo et al., 2010).

*) P33978L3: I do not agree that light dependency only means “directly released through stomata” and that temperature dependency only means “stored in the leaf pool”. It is much more complicated than that and refers in great part to the production of the compounds. So please reformulate or leave out.

*) P33982L1-5: It would be very very interesting to see what emissions ORCHIDEE and MEGAN would produce if the approach of the other model was used.

*) P33982L11-12: Guess the point is that some areas (e.g. Europe and the US) are covered quite well (though there is definitely a lack of year-round measurements), while there exists no or close to no data in other regions.

*) P33983L22-24: Reading this and looking at Fig. 1, it seems to me that what should really be tested/improved is the met forcings, since that seems to have much greater impact than the emission module.

*) P33989L3-13: Wouldn't it be better to move this to Sec. 3.5? After reading this short paragraph, I am wondering why the emission response is different, since you use the same emission algorithm (Guenther/MEGAN).

*) Table 2: Where does the LDF and Beta values come from? Why is LDF and Beta 0.6 for total monoterpenes, but no values are assigned for the individual monoterpenes? Or is the LDF and Beta values also 0.6 for all the individual monoterpenes? This is not clear. There is information about the light dependency of the individual monoterpenes, which seems to be quite large – e.g. sabinene and ocimene seems to be very light dependent (e.g. Owen et al., 2002). Please indicate what “MBO” is. Compound names should not be in capital.

*) Table 3: I understand that you have to limit, but there are much more papers available.

*) Table 4: where do these ratios come from?

*) Table 6: Why are there no estimates from MEGAN concerning limonene, myrcene, 3-carene and ocimene?

*) I am very sceptical that you predict so high isoprene emissions (especially compared to the monoterpene emissions) in northern temperate and boreal areas. This also seem to be one of your largest differences to the MEGAN model. I fear that this high isoprene emission is due to the fact that you have not considered which northern plants emit isoprene and which do not.

*) You predict higher sesquiterpene emissions in the tropics than MEGAN – why is this so? Just because the EF is increased in your simulations?

*) It would be good if you added a section in the end that would also discuss the impact of your findings? And maybe hold this together with previous studies on e.g. meteorology.

Technical corrections:

(Compact listing of purely technical corrections)

- *) There are many places where the language could be improved (not by fancy words, but just correct English – e.g. the article is sometimes missing.). I have indicated some mistakes, but there are more.
- *) You use the unit “gdm” - it is not clear to me what this means.
- *) Please provide the full institutional addresses in the affiliations.
- *) Please spell out “BVOC” first time this acronym is used (first line in abstract) and not in the intro. Same comment for “PFT” (P33969L21), which is currently first spelled out in the intro.
- *) P33969L27: It took me some time before I realised that you scaled LAI by 0.5 and 1.5. Please write this more clearly.
- *) P33970L2: “to variation of LDF” → “to variation in the LDF”.
- *) P33970L26: “largely” → “widely”.
- *) At many places, you mix UK and US English. Please homogenise.
- *) P33971L11: delete “a” and replace “variation” by “variations”.
- *) P33971L15: Don't spell out “EF” again, you have already done so. Same goes for “LAI” on P33972L19. In general: please check the whole manuscript for places where you have spelled out acronyms more than once.
- *) P33971L17: delete “is a key emission driver”, since that does not make sense – it IS the actual emission at standard conditions. Also delete “a” in front of “large variability”.
- *) P33971L28: “as one PFT can actually correspond to” → “as one PFT is actually corresponding to”, since there are always more than one species covered in a PFT.
- *) P33971L27-P33972L1: this sentence sounds broken or that something is missing.
- *) P33972L25: Replace “can affect” with “affects” and add “modelled” or “predicted” or “calculated or similar in front of “regional and seasonal distribution”.
- *) Is there no reference to STOMATE available?
- *) P33975L4: What is “LPJ”? Is it the LPJ model that provides the surface areas provided for ORCHIDEE in Table 1?
- *) P33975L16: Add “The” before “canopy”. “Divided in up to 17 LAI layers” - this sounds very weird – I guess you mean that you split the total LAI into different canopy layers – please reformulate.
- *) P33975L25: Add “the” before “leaf level”. Replace “in the” with “at”. Now I will try to stop making note on this grammar stuff – please check it yourself. There are many following mistakes.
- *) P33976L3: Add “the” before “emitted”. Since C_{TL} depends on the emitted compounds, why is it not C_{TLi} instead?
- *) P33977L1: “in order to take into...”???
- *) P33977L3: “needleaf” is misspelled here and later.
- *) P33977L8: “2-Methyl-3-Buten-2-Ol” → “2-methyl-3-buten-2-ol”.
- *) P33978L6-10: I am very confused by your symbols. Is C_{TLi} in Eq. 1 then not supposed to be $C_{TL}(l)$?
- *) P33978L13-18: Either you write out the meaning of the symbols, or you leave out the equations and only refer to Guenther et al., 1995.
- *) P33980L20+L24: “2” and “1” → “two” and “one”. Other places also with same mistake.
- *) P33981L12: Any reference or website to CRU-NCEP?
- *) P33982: “Ls”???. You have used L_c before – is that now the same?
- *) P33983L19-20: compounds does not start with a capital letter – please change it here and also other places in the text where you wrote it like that.
- *) P33988L19: Sure it's not “western Brazil”?
- *) P33989L1: “...can observe comparing...”?
- *) P33989L6-9: You start and end the line with emphasising that this is important for light-dependent emission – I think you don't have to add “in the case of BVOCs that are strongly light dependent”.
- *) P33989L21-22: Don't write about the “solid black line” and “red line”, since you confuse the reader, cause there are no such lines in Fig. 4.

- *) P33990L20: “for each” → “with each”.
- *) P33990L24-27: Please add reference to the figures that shows this.
- *) P33994L9: “non light-dependent” = “light independent”.
- *) P33995L14-20: maybe past tense works better.
- *) Table 5: “Modis Lai” = “MODIS LAI”? You must have a mistake in the LAI info column for the simulations where you multiply LAI with 1.5! Is it really so that you used the air temperature for MEG_LDF and not the leaf temperature?
- *) Figure 11: The unit is not supposed to be in italic? From your figure text “The thick and thin dashed line represent...” → “The thick and thin dashed lines represent...”. Maybe also worth to mention that the LAI peaks at different times in ORCHIDEE and MEGAN and why this is so. Also, Fig. 11 should be listed before Fig. 10, since it is mentioned in the text before Fig. 10.
- *) Figure 10: Please include the results from MEG_CRU in this figure too. It helps for the comparison.

References:

- Ghirardo et al., Plant, Cell and Environment, 33, 781, 2010.
- Mann et al., Atmos. Chem. Phys, 14, 4679, 2014.
- Owen et al., Atmos. Environ., 36, 3147, 2002.
- Spracklen and Righelato, Biogeosciences, 11, 2741, 2014.
- Tsigaridis et al., Atmos. Chem. Phys., 14, 10845, 2014.