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Article title: Global Biogenic Volatile Organic Compound emissions in the ORCHIDEE and MEGAN models and sensitivity to key parameters

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Responses to Editor's and Referees' Comments

Summary for the Editor

We thank the Editor and the Referees for the worthy and constructive comments that helped us to significantly improve the manuscript.

We summarize below the major changes made to the manuscript in order to address Editor's and Referees' major concerns.

Following Editor's and Referees' suggestion:

- we add a new section (2.2.1) dedicated to EFs where we discuss the difficulties related to the EF setting at global scale. We describe the general approach used to assign new EFs and we give some examples on how we proceed in updating the emission factor;
- we insert a new section (2.5) where we detail the differences between emission module formulations in ORCHIDEE and in MEGAN;
- we better detail the arguments supporting the usage of the ORCHIDEE LAI as input for the emission scheme. We also point out the problems still to be solved and the open questions;
- we re-organise section 3.4, differentiating more clearly the discussion on LAI uncertainties and the impact on BVOC emission estimates of LAI seasonal cycle and size. We add new sub-sections: *"3.4.1 LAI seasonal cycle impact"* and *"3.4.2 LAI size impact"*.
- we better describe the LDF parameter used in both models and the implications of the simplified assumptions of this parameterization;
- we add a new section (5) where we discuss the possible developments and the impact of our findings.
- The manuscript was read by two English native speakers to reduce, as much as possible, the grammar mistakes.

Responses to Editor's Comments

We thank Editor for his time and consideration. We closely examine the insightful and constructive comments, that have helped us to improve the manuscript.

Editor's comments are quoted in bold. Authors' answers are in regular font and authors' changes in the manuscript are quoted in italic.

We refer to the marked-up manuscript version for section numbers and pages.

Responses to General Comment

I have a comment on the light dependent fraction (LDF) of monoterpene emission, as included in Equation (2) of the manuscript. The LDFs used in the study are different for different compounds emitted, being 1 for isoprene and 0.6 for monoterpenes. However, these seem to be held constant across all plant functional types. I question the validity of this latter assumption which seems to be copied from predecessor models. According to both the light dependencies of measured monoterpene emissions (Staudt and Seufert 1995; Steinbrecher et al., 1999; Kuhn et al., 2002; Rinne et al 2002; Taipale et al., 2011) and stable isotope labeling experiments (Loreto et al., 1996; Ghirardo et al., 2010), the LDF for monoterpenes to vary from 1 for many broadleaf trees to less than 0.5 for many conifers. This issue and its implications should be at least discussed in the paper.

Authors: We are aware that this is a rather crude approximation. Nevertheless, there are currently not enough observations to define a solid global scale parameterization of LDF, which presents similar difficulties as setting EFs (first paragraph of section 3.5). Therefore, as a first step, we decided not to further detail the LDF modelling and we have chosen a single LDF value for all PTFs, as proposed in Guenther et al. 2012. We discuss this issue in more details in section 1, leaning on the references suggested by the Editor (see §1).

The sensitivity tests that we have performed prove that emissions can vary significantly depending on the LDF used. They also provide an evaluation of the error associated with a different selection of LDF. This is detailed below in §2.

At the end of section 3.5 we better detail the implication related to LDF incertitude and we change the last sentence (see §2), which in the original version leads to misinterpretations. Moreover, we add a point about this issue in section 5 (see §3).

§1 *"The Guenther et al. (2012) approach considers only one value per emitted compound, whilst it has been shown the LDF also depends on the plant species. For example, measurements of the diurnal cycle for monoterpenes above Amazonian rainforest (Rinne et al. 2002; Kuhn et al., 2002) suggest that emissions are dependent on both light and temperature, whilst the role of light in influencing monoterpene emissions from boreal Scot pine forest is less clear (Taipale et al., 2011). Moreover, Staudt and Seufert (1995) and Loreto et al. (1996) show that monoterpene emissions from coniferous trees are principally influenced by the temperature, while those from Holm oak are predominantly controlled by a light-dependent mechanism. Owen et al. (2002) find that, in the Mediterranean region, emissions of all compounds from Quercus sp. are light dependent, the ocimene emitted by Pinus pinea is strongly correlated to light and an apparent weak light dependency is exhibited by monoterpene emissions from Cistus incanus. Ghirardo et al. (2010) provide the fraction of light-dependent monoterpene emission, being 58% for Scots pine, 33.5% for Norway spruce, 9.8% for European larch, and 98–100% for both Silver birch and Holm oak. Shao et al. (2001) and Steinbrecher et al. (1999) attribute for Scots pine a value of 20–30% and 25–37%, respectively. Nevertheless, there is no general agreement on the exact value of the temperature- and light-dependent fraction to assign to individual compounds and PFTs, as it also appears from the works mentioned right above."*

§2 *"Secondly, the variable orcldf0 (megldf0) represents the emissions when LDF is zero while orcldf1 (megldf1) represents the emissions when LDF is one; thus, they define the interval spanned by emissions as LDF varies. Therefore, a low LDF index is associated with a greater variability of emissions for equal light-independent emissions. Consequently, ORCHIDEE results more sensitive to LDF variation than MEGAN, as the ORCHIDEE LDF index is lower than the MEGAN index. Furthermore, the LDF index provides an evaluation of error due to a diverse choice of LDF values. The LDF index is always less than 100, meaning that the light-independent component of the emission is always bigger than the light-dependent part. Therefore, if LDF in the model is greater than it should be, emissions will be underestimated, while if it is less, emissions will be overestimated. At regional scale, tropical areas, that are associated to high LDF index, will be less sensitive to LDF variation than other regions."*

§3 *"- model LDF parameterisation is still oversimplified and has a significant impact on emissions. Future developments should, therefore, improve LDF parameterization accuracy. For example, by including PFT dependency. As for EFs, results can be achieved only by increasing observation coverage;"*

Response to Technical Comment

Why is value for beta defined for isoprene emission, when the term where it appears in Equation (2) is zero when LDF is 1?

Authors: In the code we set arbitrary beta = 0.9 for MBO and isoprene, but indeed the beta value can be any, since the CTLI term is zero when LDF is set to1 and there is no need to specify it. We therefore remove the beta value for isoprene and MBO from the table 2 and we put "-".

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