

Interactive comments on « Implementation of the biogenic emission model MEGAN(v2.1) into the ECHAM6-HAMMOZ chemistry climate model. Basic results and sensitivity tests » by Alexandra-Jane Henrot et al.

Alexandra-Jane Henrot et al.

REFeree #2

We would like to thank Referee #2 for positive and constructive comments on our paper, and especially for the suggestions made for clarifying the calculation of the activity factors. The suggested changes will be addressed in the revised version of the manuscript.

Referee #2's comments are quoted in blue. Authors' answers are in regular font and authors' changes in the manuscript are quoted in italic.

Specific comments

Section 2.3.1 Emission activity factor gamma

I believe there is a missing parenthesis at the end of Eq. (3) and the gamma_LAI factor multiplies the light independent as well as the light dependent part. The approach to calculation of the gamma factor is a combination of the algorithm used in the newest MEGANv2.1 (Guenther et al., 2012) and the simplified parameterized approach (PCEEA) described in Guenther et al. (2006) for isoprene, i.e. for light dependent species.

The authors should make clear that the Eq. (3) as it is described is actually not used by MEGANv2.1, but already includes edits after application of PCEEA. I think it would increase clarity if the authors described with a little bit more detail how they derived Eq. (3). Guenther et al. (2006) do not discuss light-dependent and light-independent parts (as the paper is focused on isoprene only) and Guenther et al. (2012) introduce light dependent fraction factor, but do not mention the final equation for calculation of gamma_CE for both light-dependent and light-independent parts in a way as it is used in the model code (which I assume was a starting point for the presented study), therefore it is not straightforward how authors end up with Eq. (3).

I assume the construction of Eq (3) was the following and I'd suggest the authors to include its derivation (in modified way) in the manuscript.

Equation for calculation of gamma_CE in MEGANv2.1 (as written in the MEGANv2.1 code) is

$$\text{Gamma_CE} = (1 - \text{LDF}) * \text{gamma_TLI} * \text{gamma_LAI} + \text{LDF} * \text{Cce} * \text{LAI} * \text{gamma_TLD}$$

Following Guenther et al. (2006) the calculation of light-dependent factor with

detailed canopy environment model (i.e. $C_{ce} \cdot LAI \cdot \gamma_{TLD}$) was replaced by parameterized canopy environment emission activity factor ($\gamma_{LAI} \cdot \gamma_P \cdot \gamma_T$)

Equation 3 has been corrected (missing parenthesis added) as follows:

$$GAMMA_CE = GAMMA_LAI * ((1-LDF) * GAMMA_TLI + LDF * GAMMA_TLD).$$

As pointed out by Referee #2, the calculation of GAMMA_CE used in the biogenic model described here differs from the basic calculation applied in MEGANv2.1. The light-dependent activity factor GAMMA_TLD is indeed calculated using the PCEEA approach (Guenther et al., 2006), which is not the case in the equation used in MEGANv2.1. Accordingly to the suggestion of Referee #2, we have added in the revised manuscript in Section 2.3.1 a detailed description of the construction of Eq (3).

« GAMMA_CE accounts for variations associated with Leaf Area Index (LAI) ($m^2 m^{-2}$), Photosynthetic Photon Flux Density (PPFD) (μmol of photons in 400-700 nm range $m^{-2} s^{-1}$) and temperature (K). The basic equation used in the fortran code of MEGANv2.1 to calculate GAMMA_CE is:

$$GAMMA_CE = GAMMA_LAI * (1-LDF) * GAMMA_TLI + C_{ce} * LAI * LDF * GAMMA_TLD$$

where C_{ce} is the canopy environment coefficient (assigned a value that results in $GAMMA = 1$ for the standard conditions), and GAMMA_LAI, GAMMA_TLI and GAMMA_TLD are the activity factors for LAI, light and temperature. Different expressions for the activity factor for temperature are considered for light dependent (GAMMA_TLD) and light independent (GAMMA_TLI) emissions using the light dependence fraction LDF specific for each compound (Guenther et al., 2012). Light dependent emissions are calculated following the isoprene-response to temperature described in Guenther et al. (2006). Light independent emissions follow the monoterpene exponential temperature response described in Guenther et al. (1993). In order to avoid the use of a detailed canopy environment model calculating light and temperature at each canopy depth, we applied the Parameterised Canopy Environment Emission Activity (PCEEA) approach (Guenther et al., 2006). The calculation of the light-dependent activity factor with a detailed canopy environment model (i. e. $C_{ce} \cdot LAI \cdot \gamma_{TLD}$) is replaced by a parameterized canopy environment activity factor (i. e. $\gamma_{LAI} \cdot \gamma_P \cdot \gamma_T$) as described in Guenther et al. (2006). We refer the reader to the description of Guenther et al. (2006, 2012) for the details of the LAI and light-dependent activity factor computations. Detailed formula and parameters per compound class are given in Supplementary Material (Sect. S1 and S2). The equation for GAMMA_CE applied here is thus:

$$GAMMA_CE = GAMMA_LAI * ((1-LDF) * GAMMA_TLI + LDF * \gamma_P * \gamma_T).$$

»

My other comment to Eq (3) is that gamma_TLI factor (accounting for temperature dependence for light-independent species) is in MEGANv2.1 calculated for sunlit and shaded leaves at 5 canopy levels. This approach is obviously not used in the current study. I think the authors should mention the simplification they have done for calculation of the light-independent factor and eventually comment on its implications.

In agreement with the second comment of Referee #2 we have mentioned in the revised manuscript in Section 2.3.1 the simplification applied for the calculation of light-independent activity factor GAMMA_TLI and briefly discussed its implication. In the biogenic module we use the ambient air temperature instead of the leaf temperature to calculate GAMMA_TLI. This simplification was also applied in Guenther et al. (1995). We thus do not take into account in BVOC emission estimates the effect of the difference of temperature between sunlit and shaded leaves. Leaves in direct sunlight often experience temperatures that are a degree or more higher than ambient air while shaded leaves are often cooler than ambient air temperature (Guenther et al., 2012). This simplification leads to a small underestimation (<5%) of light-independent BVOC emissions accordingly to Guenther et al. (2012). The text has been completed as follows:

« The light-independent activity factor GAMMA_TLI is calculated here assuming that leaf temperature is equal to ambient air temperature. In the absence of a detailed canopy model, we do not distinguish between sunlit and shaded leaves that can show significant temperature differences. Leaves in direct sunlight often experience temperatures that are a degree or more higher than ambient air while shaded leaves are often cooler than ambient air temperature (Guenther et al., 2012). This simplification can lead to a small underestimation (< 5 %) of light-independent BVOC emissions as reported in Guenther et al. (2012). »

P7L29 : Loss of biomass (annual cycle of LAI) also contributes to seasonal variation of emissions.

The loss of biomass has been mentioned in the corrected sentence.

P13L5: Sindelarova et al. (2014) suggested that a considerable uncertainty in applying the soil moisture activity factor lies in the wilting point value which differs among the models. Authors mention the importance of wilting point selection themselves. Could they comment on why they chose 35 % of the maximum soil water content as a wilting point value?

The soil water content and wilting point used in the biogenic module are calculated in the soil water model included in ECHAM6 (Hagemann and Stacke, 2002 ; Hagemann and Stacke, 2015). In the soil water model, the permanent wilting point is set to 35% of the maximum soil water amount and we stick to this value in order to be consistent with the soil water model of ECHAM6.

P14L14-15: I suppose that the reductions of 1 Tg(C)/year for isoprene and 0.08 Tg(C)/year are averages over the modeled period. It should be mentioned in the sentence that these are mean values.

As suggested, we have modified the sentence to mention that the values reported are means over the modeled period.

P16L3-5: The authors say that “The use of emission factors derived from PFT distributions . . . results . . . to the largest changes in the spatial distribution of BVOC emissions” but it is not clear what they compare here. Largest changes compared to other simulations in the current paper?

The effect of the emission factors is indeed compared here to the sensitivity simulation results of the current study. The sentence has been amended to include this precision.

Table 6. Please revise the unit in the Table caption

The units have been corrected to 10^{12} m^2 in the table caption.

Technical comments

We have taken into account all technical corrections suggested by Referee #2.

References

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